SOIL SURVEY OF

Mahaska County, Iowa

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa Agriculture and Home Economics Experiment Station
Cooperative Extension Service, Iowa State University
and the
Department of Soil Conservation, State of Iowa

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1967–70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service; the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Mahaska County Soil Conservation District. Funds to defray part of the cost of this survey were supplied by Mahaska County.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Mahaska County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in numerical order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the woodland suitability group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and the woodland suitability groups.

Foresters and others can refer to the section "Woodland Management," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife."

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, schools, and parks and other recreational areas in the sections "Descriptions of the Soils," "Use of the Soils for Recreation," and "Engineering Uses of the Soils."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of Soils."

Newcomers in Mahaska County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

Cover: Contour stripcropping on Ladoga silt loam (*left and foreground*), Armstrong loam (*center*), and Gara loam (*lower slopes to right*).

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Issued February 1977

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SOIL SURVEY OF MAHASKA COUNTY, IOWA

BY MAX A. SHERWOOD AND JAMES R. CULVER

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION, AND COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY, AND THE DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

MAHASKA COUNTY is in the southeastern part of Iowa (fig. 1). It has a total area of 366,080 acres. In 1967, 353,016 acres were in farms, and 12,957 acres were classified as urban. Water covers 107 acres of the county. Oskaloosa, the county seat, is 60 miles southeast of Des Moines, the State Capitol.

Mahaska County had a population of 22,177 in 1970. Slightly more than half of the population lives in Oskaloosa. In 1970 the farm population was 7,950.

The economy is based on farming, but a limited amount of industrial development and open-pit mining for coal and limestone occurs. Farmland is used mainly for growing corn, soybeans, oats, meadow grasses, and legumes. Corn and soybeans are the principal crops. In 1967, 73,215 acres were in pasture and 31,000 acres were in timber. The principal livestock are hogs and beef and dairy cattle.

Most of the soils are deep and fertile. Generally the less sloping upland soils on the ridges formed in loess under prairie vegetation, and the steeper soils on hillsides formed in glacial till under forest vegetation or under a mixture of grass and trees.

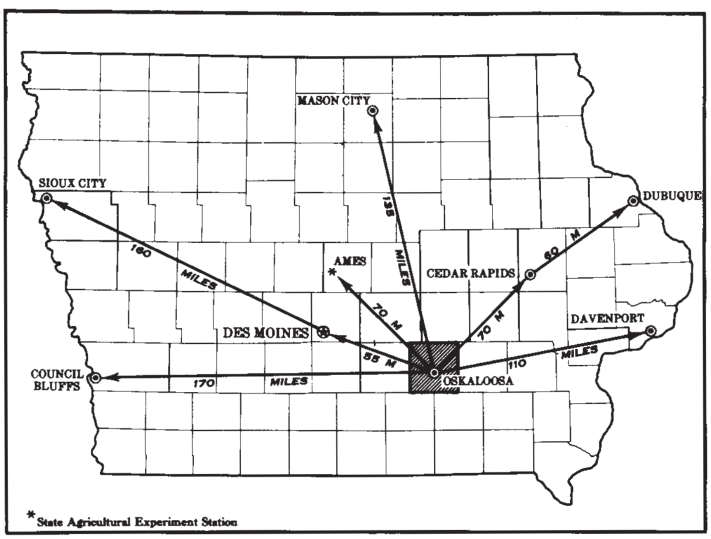


Figure 1.—**Location of Mahaska County in Iowa.**

Spring flooding of bottom land in places along the Des Moines and Skunk Rivers has been nearly an annual occurrence. The Red Rock Dam, which recently has been built, is expected to generally control this flooding.

The climate is subhumid and continental (*5*).[1] Winters are cold and summers are warm. The average growing season is 163 days.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Mahaska County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose the soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Taintor and Otley, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man (*15*).[1] On the basis of such differences, a soil series is divided into phases. The name of

[1] Italic numbers in parentheses refer to Literature Cited, p. 121.

a soil phase indicates a feature that affects management. For example, Otley silty clay loam, 5 to 9 percent slopes, moderately eroded, is one of several phases within the Otley series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit is shown on the soil map of Mahaska County—the soil complex.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Colo-Ely silty clay loams, 2 to 5 percent slopes, for example, is a soil complex in this county.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Riverwash is a land type in Mahaska County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Mahaska County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The lines on this general soil map do not exactly match those of the published Keokuk County soil survey, and the names of some adjoining soil associations are different. This was brought about mainly by better knowledge of the soils or by modification or refinement in soil series concepts.

The general soil map of Mahaska County shows seven soil associations. Six of them are on upland, and one is on bottom land. These soil associations are described in the following paragraphs.

1. Mahaska-Taintor Association

Nearly level and gently sloping, somewhat poorly drained and poorly drained soils that have a subsoil of silty clay loam or silty clay; on uplands

This association consists mainly of soils on wide ridgetops, or divides (fig. 2). These divides are at the highest elevations in the county. The larger areas of this association form the main divides between the Des Moines and Skunk Rivers.

This association occupies about 16 percent of the county. About 57 percent of the association is Mahaska soils, 38 percent is Taintor soils, and 5 percent is minor soils.

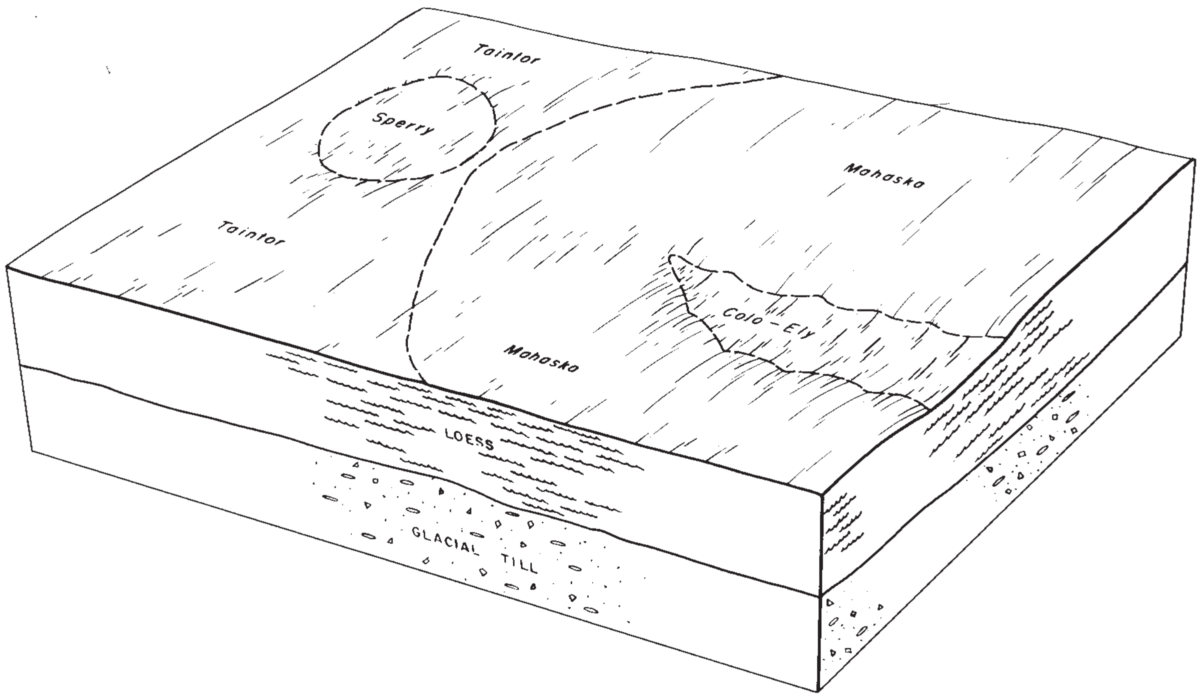
Mahaska soils are in slightly convex areas that border areas of the more level Taintor soils. They formed in loess under a cover of grasses. Mahaska soils have a surface layer of black silty clay loam and a subsoil of dark grayish-brown and grayish-brown, mottled silty clay loam. These soils are somewhat poorly drained. Tile drainage is beneficial, although the soils are cultivated in some areas without it.

Taintor soils are in the most nearly level parts of the association. They formed in loess under a cover of grasses. They have a surface layer of black silty clay loam and a subsoil of mottled, gray silty clay. Taintor soils are poorly drained. Tile drains have been installed in most areas, but in a few places improved tile outlets and larger tile mains with less space between are needed.

Among the minor soils in this association are poorly drained Sperry soils in slight depressions; somewhat poorly drained Givin soils on slightly convex, nearly level upland ridges and loess-covered high benches along streams; and poorly drained Colo and somewhat poorly drained Ely soils in drainageways.

All of the soils in the Mahaska-Taintor association have high available water capacity.

The soils in this association are well suited to crops. Corn and soybeans are the major crops. Much of the corn is fed



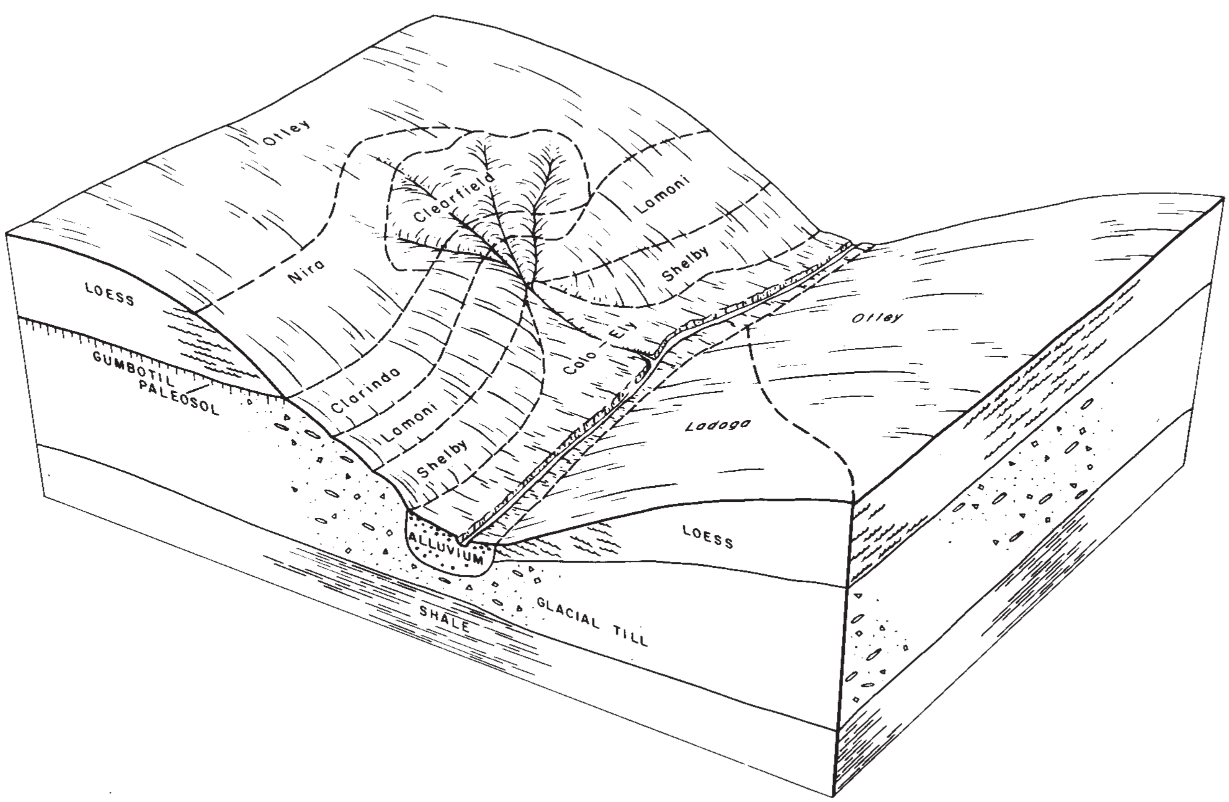


Figure 2.—**Relationship of soils in Mahaska-Taintor association (*upper*) and Otley-Ladoga-Nira association (*lower*) to landscape and parent material.**

to hogs and to beef cattle or dairy cattle. Soybeans are used mainly as a cash crop. The only permanent pasture is in small lots near farmsteads. Some farms are located entirely within this soil association. Where ownership and location of road boundaries permit it, some areas can be managed as large fields.

2. Otley-Ladoga-Nira Association

Gently sloping to strongly sloping, moderately well drained soils that have a subsoil of silty clay loam; on uplands

This association consists mainly of gently sloping soils on convex ridgetops and strongly sloping soils on side slopes that have many drainageways (figures 2 and 3). These soils form an almost contoured pattern around the heads and sides of major drainageways.

This association occupies about 31 percent of the county. About 45 percent of the association is Otley soils, 15 percent is Ladoga soils, 10 percent is Nira soils, and 30 percent is minor soils.

Otley soils are on ridgetops and the upper part of side slopes and are generally on higher areas than Ladoga soils. They formed in loess under a cover of grasses. Otley soils have a surface layer of very dark grayish-brown or very dark brown silty clay loam and a subsoil of dark-brown silty clay loam.

Ladoga soils are on tops and sides of ridges at lower elevations. These soils formed in loess under a cover of grasses and trees. Ladoga soils have a surface layer of very dark brown silt loam, a subsurface layer of dark grayish-brown silt loam, and a subsoil of dark yellowish-brown silty clay loam.

Nira soils are generally at the heads of waterways and on gently to moderately sloping side slopes. They formed in loess under a cover of grasses. These Nira soils have a surface layer of very dark brown silty clay loam and a subsoil that is dark-brown silty clay loam in the upper part. Below this, at a depth of about 22 inches, is silty clay loam that is mottled grayish brown and yellowish brown.

The minor soils in this association are poorly drained Clarinda and Clearfield soils and somewhat poorly drained Lamoni soils that are downslope from the major soils; moderately well drained Shelby soils in lower areas; and poorly drained Colo and Zook and somewhat poorly drained Ely soils in drainageways.

All of the soils in the Otley-Ladoga-Nira association have high available water capacity. Drainage generally is adequate for most crops grown in the county, but in many places a narrow, seepy band is present near the contact zone

***Figure 3.*—Landscape of Otley and Nira soils in Otley-Ladoga-Nira association.**

of the loess and the weathered glacial till on side slopes. These seep areas are most prevalent in spring. Tile drainage is beneficial where seeding is established in waterways, since the upland drainageways are often wet and seepy. Scattered trees and shrubs are along some of the waterways and old fence rows.

Farming is diversified in this association, but grain and livestock are the main farm products. Much of the acreage is used for row crops and meadow grown in rotation. These soils can be terraced, stripcropped, and tilled on the contour, since most of them have long and uniform slopes.

In this association the trend is to combine small farms into larger ones. Some farm buildings are vacant, and farmers generally operate more than one small-farm unit.

3. Clinton-Lindley-Gara Association

Gently sloping to steep, well drained and moderately well drained soils that have a subsoil of silty clay loam or clay loam; on uplands

This association consists mainly of hilly, strongly dissected soils that border flood plains of the Des Moines and Skunk Rivers and their major tributaries. Many areas of Clinton and Lindley soils have been cleared of trees and are used for pasture (fig. 4). Characteristic features of areas of this association are narrow, rounded ridgetops; long, steep, convex side slopes, and narrow upland valleys (fig. 5). Also in the association are small wooded areas; scattered trees in gullies and along fence rows; small, irregularly shaped fields; and many acres of pasture.

This association occupies about 21 percent of the county. About 35 percent of the association is Clinton soils, 17 percent is Lindley soils, 9 percent is Gara soils, and 39 percent is minor soils.

Clinton soils are on rounded ridgetops and the upper parts of convex side slopes. These soils are gently sloping to moderately steep. They formed in loess under a cover of trees. Clinton soils have a surface layer of very dark grayish-brown silt loam, a subsurface layer of brown silt loam, and a subsoil of brown to yellowish-brown silty clay loam. Clinton soils are moderately well drained.

Lindley soils are on the lower part of side slopes of dissected upland divides. These soils are strongly sloping to steep. They are at lower elevations than Clinton soils. These Lindley soils formed in glacial till under a cover of trees. These soils have a surface layer of very dark gray loam, a subsurface layer of dark grayish brown, and a subsoil of yellowish-brown clay loam. Lindley soils are well drained and moderately well drained.

Figure 4.—Landscape of Clinton soils on ridgetops and Lindley soils on sides of ridges.

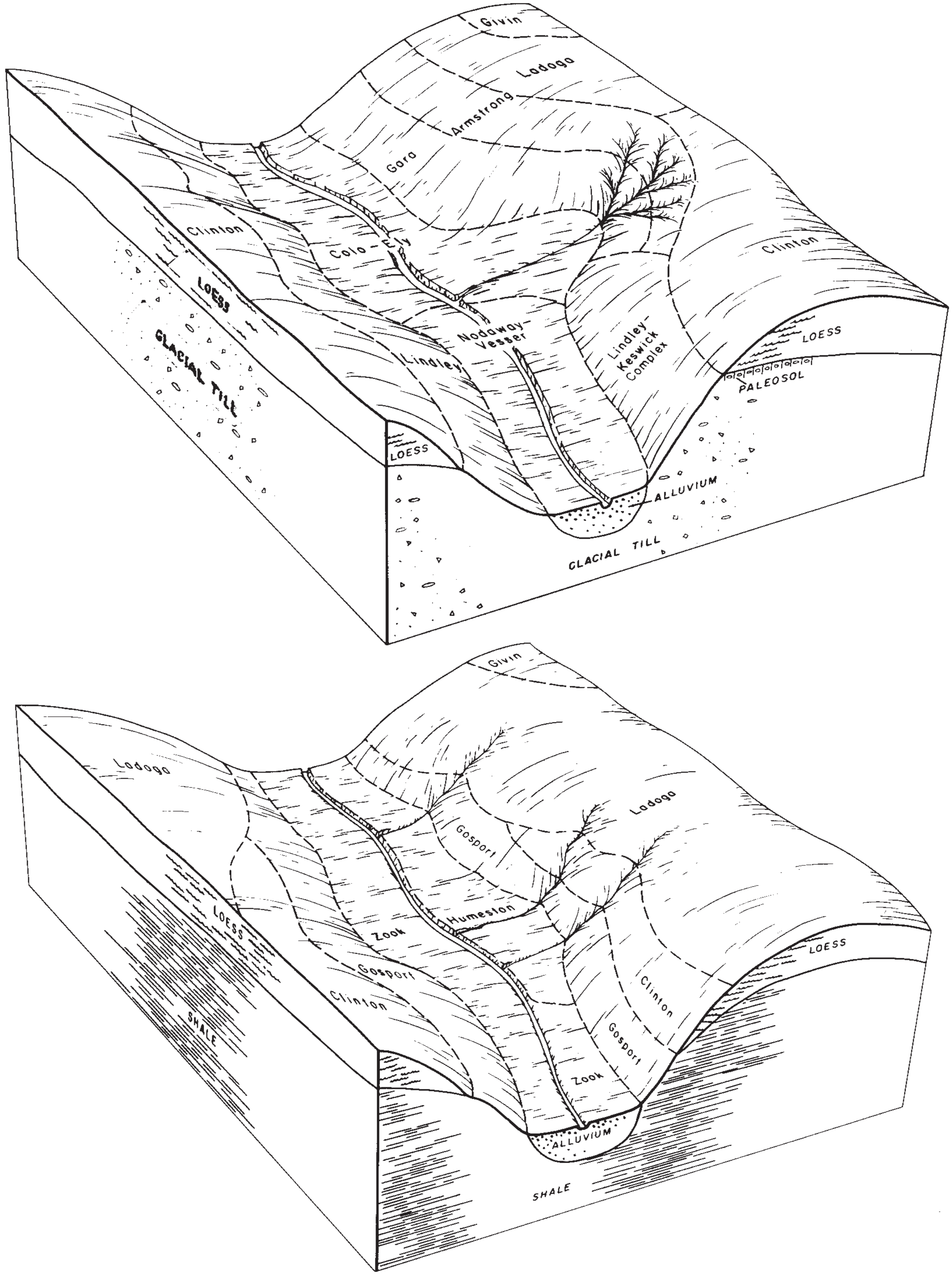


***Figure 5.*—Relationship of soils in Clinton-Lindley-Gara association (*upper*) and Ladoga-Clinton-Gosport association (*lower*) to landscape and parent material.**

Gara soils are on the lower part of convex uplands. These soils are strongly sloping to steep. They are generally at lower elevations than Ladoga soils. These Gara soils formed in glacial till under a cover of grasses and trees. They have a surface layer of very dark gray loam, a subsurface layer of dark grayish-brown loam, and a subsoil of dark yellowish-brown clay loam. Gara soils are well drained and moderately well drained.

Ladoga soils are dominant among the minor soils in this association. These soils are moderately well drained. They formed in loess and are on rounded ridgetops and the upper parts of convex side slopes.

Other minor soils in this association are the somewhat poorly drained Givin soils on ridgetops; the somewhat poorly drained Armstrong and Keswick soils and the moderately well drained Hedrick soils on the upper part of side slopes; the moderately well drained Caleb soils and the well-drained Fayette and Seaton soils on the middle and lower parts of side slopes; and the Colo-Ely silty clay loams and Nodaway-Vesser silt loams in drainageways.

The soils in the Clinton-Lindley-Gara Association have a high available water capacity. In many areas runoff is rapid, and the hazard of erosion is moderate to severe. The contact zone between the loess and glacial till is seasonally wet and seepy. Many waterways dissect this association. Trees and brush grow along the sides of deep active gullies that are more numerous than in the other associations. Numerous ponds for watering livestock help to stabilize many of the gullies.

This association is mostly moderately suited to row crops. Row crops grow on ridgetops and upper parts of side slopes, but a large part of the acreage is in meadow, permanent pasture, and trees.

Abandoned farmsteads are common in this association. Some of the farms are along the edges of larger valleys, and others are on ridgetops. Many farmers use the soils in this association for pasture and use the adjoining bottom land for row crops.

4. Ladoga-Clinton-Gosport Association

Gently sloping to steep, moderately well drained soils that have a subsoil of silty clay loam or clay loam; on uplands

This association consists of hilly, strongly dissected soils that border the valleys of the Des Moines and Skunk Rivers and their major tributaries. (See fig. 5.) Where the main stems of upland drains are in this association, gullies and noncrossable drains often cut into drainageways. In many places trees are scattered in the drainageways and along fences. Timber grows in a few small, irregularly shaped areas, but most of the trees are near farmsteads.

This association occupies about 13 percent of the county. About 55 percent of the association is Ladoga soils, 20 percent is Clinton soils, 18 percent is Gosport soils, and 7 percent is minor soils.

Ladoga soils are on rounded ridgetops and the upper part of convex side slopes. These soils are gently sloping to strongly sloping. They formed in loess under a cover of grasses and trees. Ladoga soils have a surface layer of very dark-brown silt loam, a subsurface layer of dark grayish-brown silt loam, and a subsoil of dark yellowish-brown silty clay loam.

The Clinton soils are on rounded ridgetops and the upper part of convex side slopes. These soils are gently sloping to moderately steep. They formed in loess under a cover of trees. Clinton soils have a surface layer of very dark grayish-brown silt loam, a subsurface layer of brown silt loam, and a subsoil of brown to yellowish-brown silty clay loam.

The moderately steep and steep Gosport soils are at lower elevations. They formed in shale under a cover of grass and trees and are moderately deep to shale. These Gosport soils have a surface layer of very dark grayish-brown silt loam, a subsurface layer of grayish-brown silt loam, and a subsoil of mottled grayish-brown silty clay. Below this, at a depth of about 24 inches, is acid shale.

Among the minor soils in this association are the somewhat poorly drained Givin soils on ridgetops and the following soils on the upper parts of side slopes: the poorly drained Clarinda; the somewhat poorly drained Lamoni; the moderately well drained Nira, Gara, and Lindley; and the well-drained Hedrick soils. Minor soils that formed in weathered limestone and sandstone are Boone (sandstone) and Sogn (limestone). Minor soils that are in drainageways are Nodaway-Vesser silt loams.

All of the soils in this association except Gosport have high available water capacity. Gosport soils have moderately high available water capacity. Most areas of these soils that are on ridgetops are moderately well drained, but in many places a narrow band of wet, seepy soil develops near the contact zone of the loess and shale in spring.

Ladoga and Clinton soils are mostly moderately suited to row crops; Gosport soils are not suited to crops. Row crops are grown along the ridgetops, but side slopes are generally in meadow or permanent pasture. Deep active gullies where trees and brush grow along the sides are numerous. Many ponds are present for watering livestock.

Many abandoned open pit coal mines and spoil banks and a few active coal mines are in this association. The abandoned mines and spoil banks detract greatly from the appearance of the landscape. Idle land within and surrounding these areas is used by wildlife, but the spoil banks are too acid to produce vegetation and remain almost completely barren. A few active and abandoned limestone quarries are present in this association.

5. Colo-Nodaway-Zook Association

Nearly level and gently sloping, poorly drained to moderately well drained soils that are dominantly silty clay loam and silt loam throughout or that have a subsoil of silty clay loam or silty clay; on bottom lands

This association consists of soils on bottom lands (fig. 6) along the Des Moines and Skunk Rivers and their tributaries.

This association occupies about 15 percent of the county. About 25 percent of the association is Colo soils, 18 percent is Nodaway soils, 15 percent is Zook soils, and 42 percent is minor soils.

Colo soils are on smooth bottom lands along major rivers and their tributaries and on alluvial fans at the base of some upland slopes. These soils are poorly drained. They often lie between the Nodaway soils next to the stream channel and Zook soils, which are generally some distance from the stream channel. Colo soils formed in silty alluvium. They have layers of black silty clay loam to a depth of about 58 inches. Below this is gray silty clay loam.

Nodaway soils are generally adjacent to the present stream channel, but they may occur at some distance from it where the channel has been straightened. These soils are moderately

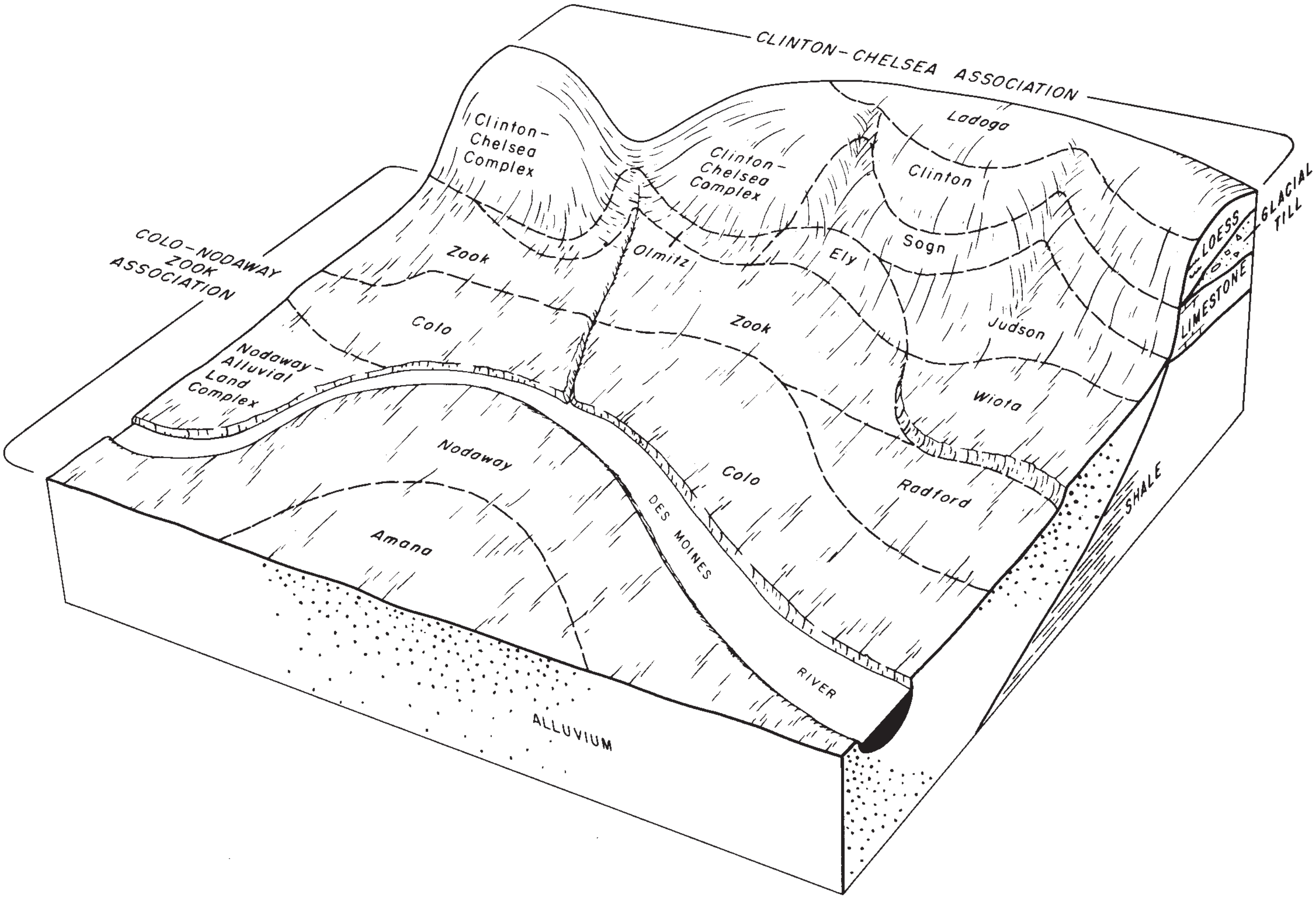


***Figure 6.*—Relationship of soils in Colo-Nodaway-Zook association and Clinton-Chelsea association to landscape and parent material.**

well drained. Nodaway soils formed in stratified silty alluvium. They have stratified dark grayish-brown silt loam and light silty clay loam to a depth of 60 inches or more.

Zook soils are on the low, flat part of bottom lands and are generally some distance from the stream channel. They formed in silty and clayey alluvium. Zook soils have a surface layer of black silty clay loam and a subsoil of very dark gray silty clay.

Among the minor soils in this association are the poorly drained Bremer, Humeston, Ossian, Radford, and Tuskeego soils and the somewhat poorly drained Amana, Ely, Nevin, Spillville, and Vesser soils. The minor soils that are moderately well drained are the Huntsville, Judson, Landes, Olmitz, Watkins, and Wiota soils. The poorly drained soils are generally on first bottoms, the somewhat poorly drained soils are on second bottoms, and the moderately well drained soils are on low benches or fans.

These soils have high available water capacity. Colo soils can generally be tiled to provide drainage if outlets are available. Tile drainage is generally not needed on Nodaway soils. Zook soils generally stay wet longer in the spring than Colo and Nodaway soils. If tile is used to provide drainage, it should be spaced closer than in Colo soils.

Most of the acreage in crops on farms in this association is used for row crops. Where areas are drained and adequately protected from flooding, these soils are well suited to row crops. Areas in permanent pasture are near stream channels or old oxbows and are flooded frequently. The farmers generally grow grain as a cash crop, but some of the grain is fed to livestock.

6. Clinton-Chelsea Association

Moderately sloping to steep, moderately well drained and excessively drained soils that have a subsoil of silty clay loam or that are loamy fine sand and fine sand throughout; on uplands

This association consists of soils that occur in complex patterns. These soils are generally in rather small areas adjacent to the east or south side of the valley of one of the larger streams in the county. These areas have convex slopes and consist of soils that formed in sandy and silty material deposited by wind.

This association occupies about 2 percent of the county. About 45 percent of the association is Clinton soils, 20 percent is Chelsea soils, and 35 percent is minor soils.

Clinton soils occur mostly as a complex with Chelsea soils in this association. They are moderately sloping to steep and are moderately well drained. Clinton soils are generally in

the lower areas, and Chelsea soils are in the higher areas. The Clinton soils formed in loess under a cover of trees. They have a surface layer of very dark grayish-brown silt loam, a subsurface layer of brown silt loam, and a subsoil of brown and yellowish-brown silty clay loam.

Chelsea soils are generally adjacent to the Des Moines, North Skunk, and South Skunk Rivers. They are moderately sloping to steep and are excessively drained. They formed in sandy material under a cover of trees. These soils have a surface layer of brown loamy fine sand that is underlain by yellowish-brown loamy fine sand and fine sand to a depth of 60 inches or more.

The minor soils in this association are the Sparta, Downs, Fayette, Ladoga, Sogn, and Seaton soils where slopes are convex and the Colo-Ely silt loams in drainageways.

Chelsea soils have a low available water capacity, and Clinton soils have a high available water capacity.

Soils in this association are best suited to the growth of grass and legumes for hay, meadow, or permanent pasture. These soils are farmed where slopes are moderate. The sandy soils are droughty, however, and soil blowing is a hazard. A few small sandy areas are used to grow watermelons or Christmas trees. The more steeply sloping areas in this association have a good potential for wildlife habitat.

7. Pershing-Grundy-Haig Association

Moderately sloping to nearly level, moderately well drained to poorly drained soils that have a subosil of silty clay and silty clay loam; on uplands

This association consists mainly of soils on ridgetops and upper part of divides that have the highest elevations in the extreme southwest part of Mahaska County (fig. 7).

This association occupies about 2 percent of the county. About 36 percent of the association is Pershing soils, 23 percent is Grundy soils, 9 percent is Haig soils, and 32 percent is minor soils.

Pershing soils are generally adjacent to the Grundy soils along the edges of upland divides. These soils are moderately well drained and have gentle and moderate convex slopes. They formed in loess under a cover of grasses and trees. Pershing soils have a surface layer of very dark grayish-brown silt loam, a subsurface layer of dark grayish-brown silt loam, and a subsoil of dark grayish-brown silty clay.

Grundy soils are on slightly convex areas bordering nearly level Haig soils. Grundy soils are somewhat poorly drained. They formed in loess under a cover of grass. They have a surface layer of black silty clay loam and a subsoil of very dark gray light silty clay. Tile drainage is generally beneficial

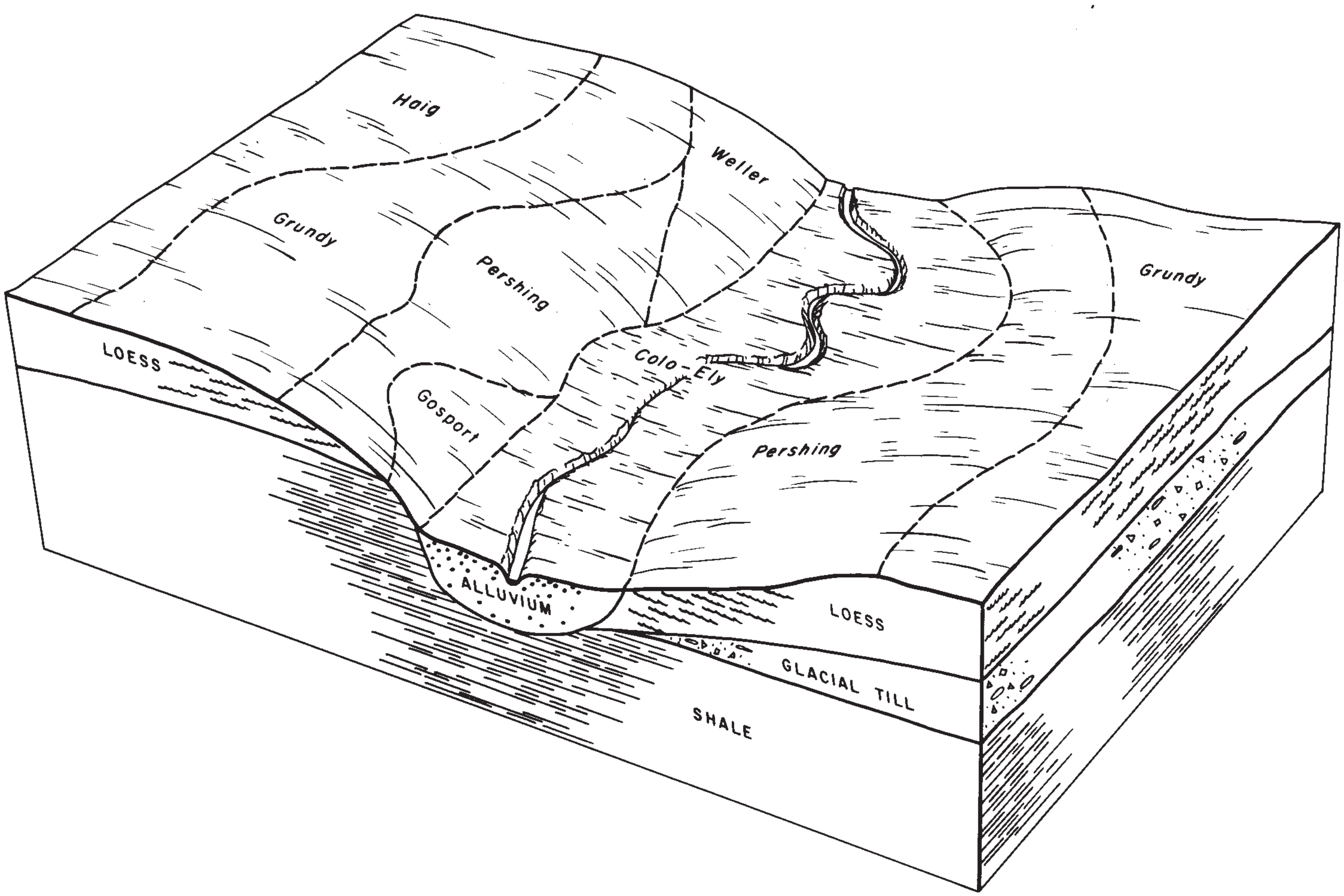


Figure 7.—**Relationship of soils in Pershing-Grundy-Haig association to landscape and parent material.**

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Amana silty clay loam, 0 to 2 percent slopes	1,620	0.4
Amana complex, channeled, 0 to 2 percent slopes	1,510	.4
Armstrong loam, 9 to 14 percent slopes, moderately eroded	1,200	.3
Boone fine sandy loam, 18 to 40 percent slopes	1,910	.5
Bremer silty clay loam, 0 to 2 percent slopes	1,710	.5
Caleb loam, 9 to 14 percent slopes, moderately eroded	290	.1
Caleb loam, 14 to 18 percent slopes, moderately eroded	1,810	.5
Caleb loam, 18 to 25 percent slopes, moderately eroded	500	.1
Chelsea loamy fine sand, 4 to 9 percent slopes	400	.1
Chelsea loamy fine sand, 9 to 14 percent slopes, moderately eroded	370	.1
Chelsea loamy fine sand, 14 to 18 percent slopes, moderately eroded	310	.1
Chelsea loamy fine sand, 18 to 25 percent slopes, moderately eroded	320	.1
Chelsea-Clinton complex, 5 to 9 percent slopes, moderately eroded	210	.1
Chelsea-Clinton complex, 9 to 14 percent slopes, moderately eroded	320	.1
Chelsea-Clinton complex, 14 to 18 percent slopes, moderately eroded	310	.1
Clarinda silty clay loam, 5 to 9 percent slopes	720	.2
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	1,470	.4
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	1,330	.4
Clearfield silty clay loam, 5 to 9 percent slopes	1,010	.3
Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded	800	.2
Clinton silt loam, 2 to 5 percent slopes	4,260	1.2
Clinton silt loam, 5 to 9 percent slopes	1,240	.3
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	13,120	3.6
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	14,940	4.0
Clinton soils, 9 to 14 percent slopes, severely eroded	720	.2
Clinton silt loam, 14 to 18 percent slopes, moderately eroded	4,720	1.3
Colo silt loam, overwash, 0 to 2 percent slopes	2,370	.7
Colo silty clay loam, 0 to 2 percent slopes	5,400	1.5
Colo silty clay loam, 2 to 5 percent slopes	670	.2
Colo-Ely silty clay loams, 2 to 5 percent slopes	16,760	4.5
Downs silt loam, benches, 2 to 5 percent slopes	330	.1
Ely silty clay loam, 2 to 5 percent slopes	810	.2
Fayette silt loam, 2 to 5 percent slopes	600	.2
Fayette silt loam, 5 to 9 percent slopes, moderately eroded	720	.2
Fayette silt loam, 9 to 14 percent slopes, moderately eroded	1,260	.3
Fayette silt loam, 14 to 18 percent slopes, moderately eroded	890	.2
Flagler fine sandy loam, 0 to 2 percent slopes	550	.1
Gara loam, 9 to 14 percent slopes, moderately eroded	2,470	.7
Gara loam, 14 to 18 percent slopes, moderately eroded	2,560	.7
Gara loam, 18 to 25 percent slopes, moderately eroded	780	.2
Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded	720	.2
Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	750	.2
Givin silt loam, 1 to 3 percent slopes	2,130	.6
Givin silt loam, benches, 1 to 3 percent slopes	1,060	.3
Gosport silt loam, 9 to 14 percent slopes	3,020	.8
Gosport silt loam, 14 to 18 percent slopes	2,290	.6
Gosport silt loam, 18 to 25 percent slopes	1,630	.4
Grundy silty clay loam, 2 to 5 percent slopes	980	0.3
Grundy silty clay loam, 5 to 9 percent slopes, moderately eroded	720	.2
Haig silt loam, 0 to 2 percent slopes	710	.2
Hedrick silt loam, 2 to 5 percent slopes	720	.2
Hedrick silt loam, 5 to 9 percent slopes	1,230	.4
Hedrick silt loam, 5 to 9 percent slopes, moderately eroded	3,920	1.1
Hedrick silt loam, 9 to 14 percent slopes, moderately eroded	3,480	1.0
Hedrick silt loam, 14 to 18 percent slopes, moderately eroded	450	.1
Humeston silt loam, 0 to 2 percent slopes	430	.1
Huntsville silt loam, 0 to 2 percent slopes	590	.2
Judson silty clay loam, 2 to 5 percent slopes	1,440	.4
Judson silty clay loam, 5 to 9 percent slopes	450	.1
Kennebec silt loam, 0 to 2 percent slopes	2,010	.6
Ladoga silt loam, 2 to 5 percent slopes	12,890	3.5
Ladoga silt loam, 5 to 9 percent slopes	4,990	1.4
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	15,880	4.3
Ladoga silt loam, 9 to 14 percent slopes	780	.2
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	9,810	2.7
Ladoga silt loam, benches, 2 to 5 percent slopes	1,520	.4
Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded	1,160	.3
Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	840	.2
Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	3,360	1.0
Landes fine sandy loam, 0 to 2 percent slopes	680	.2
Lindley loam, 9 to 14 percent slopes, moderately eroded	360	.1
Lindley loam, 14 to 18 percent slopes, moderately eroded	2,900	.8
Lindley loam, 18 to 25 percent slopes, moderately eroded	3,370	.9
Lindley-Keswick complex, 9 to 14 percent slopes, moderately eroded	1,840	.5
Lindley-Keswick complex, 14 to 18 percent slopes, moderately eroded	5,360	1.5
Mahaska silty clay loam, 0 to 2 percent slopes	23,860	6.5
Mahaska silty clay loam, 2 to 5 percent slopes	13,030	3.6
Mahaska silty clay loam, benches, 1 to 3 percent slopes	700	.2
Marsh	230	.1
Mine pits and dumps	3,190	.9
Nevin silty clay loam, 0 to 2 percent slopes	650	.2
Nira silty clay loam, 2 to 5 percent slopes	3,860	1.0
Nira silty clay loam, 5 to 9 percent slopes	4,470	1.2
Nira silty clay loam, 5 to 9 percent slopes, moderately eroded	4,780	1.3
Nodaway silt loam, 0 to 2 percent slopes	9,690	2.6
Nodaway silt loam, channeled, 0 to 2 percent slopes	1,130	.3
Nodaway-Alluvial land complex, 0 to 2 percent slopes	2,620	.7
Nodaway-Vesser silt loams, 2 to 5 percent slopes	4,490	1.2
Olmitz loam, 2 to 5 percent slopes	460	.1
Olmitz loam, 5 to 9 percent slopes	280	.1
Ossian silt loam, 0 to 2 percent slopes	1,610	.4
Otley silty clay loam, 2 to 5 percent slopes	23,490	6.4
Otley silty clay loam, 5 to 9 percent slopes	7,120	2.0
Otley silty clay loam, 5 to 9 percent slopes, moderately eroded	13,470	3.7
Otley silty clay loam, 9 to 14 percent slopes	1,240	.3
Otley silty clay loam, 9 to 14 percent slopes, moderately eroded	1,440	.4
Otley silty clay loam, benches, 2 to 5 percent slopes	860	.2
Otley silty clay loam, benches, 5 to 9 percent slopes, moderately eroded	320	.1

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Pershing silt loam, 2 to 5 percent slopes	1,050	0.3	Spillville loam, sandy substratum, 0 to 2 percent slopes	490	0.1
Pershing silt loam, 5 to 9 percent slopes, moderately eroded	1,660	.5	Taintor silty clay loam, 0 to 2 percent slopes	25,220	6.9
Radford silt loam, 0 to 2 percent slopes	3,650	1.0	Taintor silty clay loam, benches, 0 to 2 percent slopes	340	.1
Riverwash	290	.1	Tuskeego silt loam, 0 to 2 percent slopes	880	.2
Rubio silt loam, 0 to 2 percent slopes	520	.1	Vesser silt loam, 0 to 2 percent slopes	1,000	.3
Seaton silt loam, 9 to 14 percent slopes, moderately eroded	360	.1	Vesser silt loam, 2 to 5 percent slopes	1,020	.3
Seaton silt loam, 14 to 18 percent slopes, moderately eroded	720	.2	Watkins silt loam, 0 to 2 percent slopes	240	.1
Seaton silt loam, 18 to 25 percent slopes, moderately eroded	870	.2	Watkins silt loam, 2 to 5 percent slopes	350	.1
Shelby loam, 9 to 14 percent slopes, moderately eroded	630	.2	Weller silt loam, 5 to 9 percent slopes, moderately eroded	500	.1
Shelby loam, 14 to 18 percent slopes, moderately eroded	260	.1	Wiota silt loam, 0 to 2 percent slopes	720	.2
Sogn silt loam, 18 to 40 percent slopes	650	.2	Zook silt loam, overwash, 0 to 2 percent slopes	2,010	.5
Sparta loamy fine sand, 4 to 9 percent slopes	250	.1	Zook silty clay loam, 0 to 2 percent slopes	6,800	1.8
Sparta-Otley complex, 5 to 9 percent slopes, moderately eroded	430	.1	Zook silty clay loam, 2 to 5 percent slopes	1,880	.5
Sparta-Otley complex, 9 to 14 percent slopes, moderately eroded	340	.1	Zook silty clay loam, depressional, 0 to 1 percent slopes	430	.1
Sperry silt loam, 0 to 2 percent slopes	270	.1	Borrow pits	40	(1)
Spillville loam, 0 to 2 percent slopes	600	.2	Quarries	380	.1
			Sand and gravel pits	320	.1
			Made land	160	(1)
			Total	366,080	100.0

[1] Less than 0.05 percent.

on Grundy soils, but close spacing is needed between tile lines because of the clayey subsoil.

Haig soils are in the most nearly level parts of the association. They formed in loess under a cover of grass. These soils have a surface layer of black silt loam and a subsoil of grayish-brown and olive-gray silty clay. Tile drainage is generally beneficial, but close spacing is needed between tile lines because of the clayey subsoil.

Among the minor soils in this association are the moderately well drained Weller and Gosport soils and the somewhat poorly drained Lamoni soils on convex ridge crests and sides of valleys. Minor soils that are in drainageways are Colo-Ely silt loams.

The soils in this association have high available water capacity. They are well or moderately well suited to crop growth. The soils are generally used to grow corn, soybeans, hay or meadow crops, and oats. Small areas are used for permanent pasture. Few farms are located entirely within this association.

Descriptions of the Soils

This section describes the soil series and mapping units in Mahaska County. Each soil series is described in considerable detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Unless it is otherwise stated, the colors given in the descriptions are those of a moist soil.

As mentioned in the section "How This Survey Was Made," not all mapping units are in a soil series. Riverwash and Marsh, for example, do not belong to a soil series, but nevertheless, are listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit and woodland suitability group in which the mapping unit has been placed. The page for the description of each capability unit and woodland suitability group can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*15*).

Amana Series

The Amana series consists of deep, somewhat poorly drained soils that formed in silty alluvium. These soils are on smooth flood plains. Slopes are 0 to 2 percent. Remnants of stream meanders and natural levees are present in places. Native vegetation was trees and grass.

In a representative profile the surface layer is black, very dark brown, and very dark grayish-brown light silty clay loam about 16 inches thick. The subsoil, about 48 inches thick, is dark grayish-brown silty clay loam. Below a depth of 24 inches the subsoil is mottled, and the mottling increases with depth. The underlying material, at a depth of about

64 inches, is mottled, grayish-brown and yellowish-brown silt loam.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is high in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium. The water table is at a depth of less than 3 feet in spring, and unprotected areas are frequently flooded at this time. Areas of these soils that are protected from flooding are well suited to row crops.

Representative profile of Amana silty clay loam, 0 to 2 percent slopes, in a cultivated area in the valley of the South Skunk River, 444 feet north and 135 feet west of the SE corner of NE¼ sec. 20, T. 76 N., R. 16 W.:

Ap—0 to 10 inches, black (10YR 2/1) light silty clay loam; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A3—10 to 16 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) light silty clay loam; moderate, fine and medium, granular structure; friable; medium acid; clear, smooth boundary.

B1—16 to 24 inches, dark grayish-brown (10YR 4/2) light silty clay loam; moderate, fine and medium, subangular blocky structure; friable; medium acid; clear, smooth boundary.

B21—24 to 31 inches, dark grayish-brown (10YR 4/2) light silty clay loam; few, fine, faint mottles of dark yellowish brown (10YR 4/4); moderate, fine and medium, subangular blocky structure; friable; common light-gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B22—31 to 43 inches, dark grayish-brown (10YR 4/2) light silty clay loam; many, fine, faint mottles of dark yellowish brown (10YR 4/4) and light brownish gray (10YR 6/2); weak, fine, prismatic structure that parts to moderate, fine, subangular blocky; friable; common gray silt coatings on ped faces; medium acid; gradual, smooth boundary.

B3—43 to 64 inches, mottled, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) light silty clay loam; weak, fine, prismatic structure; friable; many gray silt coatings and thin, discontinuous clay films on ped faces; slightly acid; gradual, smooth boundary.

C—64 to 72 inches, mottled, grayish-brown (2.5Y 5/2) and brownish-yellow (10YR 6/6) silt loam; massive; friable; few, medium, soft black oxides; slightly acid.

The A1 or Ap horizon is typically light silty clay loam but ranges to silt loam in some places. It is black (10YR 2/1) or very dark brown. The A horizon ranges from 10 to 20 inches in thickness. The B2 horizon is dark grayish brown (10YR 4/2) to grayish brown (2.5Y 5/2). It is heavy silt loam to light silty clay loam. The most acid part of the solum is commonly medium acid but ranges to strongly acid in some places.

Amana soils are associated with Colo, Ely, Kennebec, Ossian, and Vesser soils. They are unlike Vesser soils in that they lack a grayish-colored A2 horizon and do not have as much clay in the B horizon. Amana soils have a thinner dark A horizon than Kennebec, Ely, and Colo soils. They have a browner B horizon than Ossian soils.

Amana silty clay loam, 0 to 2 percent slopes (422).—This soil is smooth or has gently undulating slopes and is on flood plains along the larger creeks, streams, and rivers in the county. Areas are irregular in shape and about 10 to 50 acres in size. This soil has the profile described as representative for the Amana series.

Included with this soil in mapping are small areas of Ossian, Kennebec, Nodaway, Colo, and Zook soils. Also included are small areas of this Amana soil that have 7 to 18 inch accumulations on the surface of sandy overwash material. These overwash materials are lighter colored and dominantly fine sand or loamy fine sand but are fine sandy loam in places. These are indicated on the soil map by a sand spot symbol.

Runoff is slow on this soil. Wetness is a hazard in spring because of temporary flooding, unless the soil is protected. The surface layer is friable and easy to till. Tilth is good.

This soil can be used intensively for corn and soybeans where it is protected. Areas not protected from flooding are often used for pasture. Capability unit I-2; woodland suitability group 5w2.

Amana complex, channeled, 0 to 2 percent slopes (C422).—This complex has gently undulating or smooth slopes and is on bottom lands that have been dissected by shallow stream channels. It is present in places along the channels of the larger streams in the county. Undulations and channels commonly form a complex curved pattern of long and narrow ridges and swales. These ridges and swales are usually 10 to 30 feet across and 50 to several hundred feet in length. Within a mapping unit, the elevation difference is commonly 1 to 3 feet. Areas are generally 20 to more than 80 acres in size. The Amana soil is on ridges and makes up about 50 percent of the complex. The Nodaway and Kennebec soils are also on ridges and make up 20 percent of the complex. The Zook and Colo soils are in the swales and make up about 30 percent of the complex.

Included with this complex in mapping are small areas of Amana soil that have 7 to 18 inches of light-colored sandy overwash material in some places. These are shown on the soil map by a special symbol.

Runoff is slow on this complex, and water often stands temporarily in swales. This complex is subject to overflow from hard rains (fig. 8) and has a high water table in wet seasons, unless it is protected and drained. The surface layer is friable, and tilth is good except in the swales.

This complex is moderately well suited to row crops and well suited to hay if protected from flooding. Most areas are in heavily wooded pasture. Capability unit Vw-1; woodland suitability group 5w2.

Armstrong Series

The Armstrong series consists of deep, moderately well drained or somewhat poorly drained soils on uplands. These soils formed in fine-textured horizons of old glacial till that were formed during an earlier geologic period and later

Figure 8.—**Flooding on bottom land, Amana complex, channeled.**

buried under loess. The Armstrong soils formed after the old buried soils were exposed by geologic erosion. Slopes are convex and range from 5 to 14 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark brown loam 8 inches thick. The subsurface layer is dark grayish-brown loam 6 inches thick. The subsoil extends to a depth of 60 inches or more. The subsoil, above the pebble band at a depth of 23 inches, is mottled reddish-brown, dark-brown, and dark-gray clay loam. Below this band, the subsoil is brown light clay that has a few mottles of grayish brown, brownish yellow, and red to a depth of 35 inches. Between depths of 35 and 60 inches, the subsoil is reddish-yellow clay loam that is high in sand and has brown coatings on ped faces. The underlying material is weathered glacial till.

Available water capacity is high in these soils. Permeability is slow. These soils are seasonably wet and seepy in areas near their boundary where soils upslope formed in more permeable loess. The surface layer is generally medium acid unless it has been limed, and it is low or moderate in content of organic matter. The subsoil is very low in available phosphorus and potassium.

Armstrong soils are moderately well suited to hay and are poorly suited to row crops.

Representative profile of Armstrong loam, 9 to 14 percent slopes, moderately eroded, in a pasture 291 feet west and 114 feet north of the SE. corner of SW¼NE¼ sec. 10, T. 76 N., R. 16.:

A1—0 to 8 inches, very dark brown (10YR 2/2) loam, grayish brown (10YR 5/2) when dry; weak, fine and very fine, granular structure; friable; common roots; medium acid; gradual, smooth boundary.

A2—8 to 14 inches, dark grayish-brown (10YR 4/2) loam, mixed grayish brown (10YR 5/2) and yellowish brown (10YR 5/4) when dry; weak, medium, platy structure that breaks to weak, fine, subangular blocky; friable; common roots; medium acid; clear, smooth boundary.

B21—14 to 23 inches, mottled, dark-gray (10YR 4/1), reddish-brown (5YR 4/4), and brown (7.5YR 4/4) clay loam high in content of sand; weak, medium, subangular blocky structure; friable; common gray silt coatings; stone line at a depth of 23 inches; medium acid; clear, smooth boundary.

IIB22t—23 to 35 inches, brown (7.5YR 4/4) light clay; few, medium, distinct mottles of grayish brown (10YR 5/2), brownish yellow (10YR 6/6), and red (2.5YR 4/6); weak, medium, subangular blocky structure; firm; thin, discontinuous clay films and very dark grayish-brown (10YR 3/2) organic stains on ped faces; strongly acid; gradual, smooth boundary.

IIB3—35 to 60 inches, reddish-yellow (7.5YR 6/8) heavy clay loam high in content of sand; brown (7.5YR 5/2) coatings on ped faces; weak, medium, prismatic structure that parts to weak, medium, subangular blocky; firm; moderately thick, discontinuous clay films and very dark grayish-brown (10YR 3/2) organic stains; few, medium, soft black oxides; strongly acid.

The A1 horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) where it has not been cultivated. It ranges from silt loam to loam or clay loam. The A2 horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3). It is loam or heavy silt loam. Depth to the IIB2t horizon ranges from 12 to 24 inches. The IIB2t horizon ranges in texture from heavy clay loam to clay. Depth to the C horizon ranges from 48 to 80 inches.

Armstrong soils are associated with Gara and Lindley soils and formed in material similar to that of the Lamoni soils. They have a thinner A1 horizon than Lamoni soils. Lamoni soils do not have an A2 horizon. Armstrong soils are higher in content of clay in the B2t horizon than Gara and Lindley soils. The B horizon in Armstrong soils is redder than those of Lamoni, Gara, and Lindley soils.

Armstrong loam, 9 to 14 percent slopes, moderately eroded (792D2).—This soil has convex slopes and is on uplands where geologic erosion has re-exposed the reddish clayey material. It is generally in an irregularly shaped band or strip that is just downslope from the loess-glacial till contact line. Areas run on the contour around hill slopes, around nose slopes, and in coves at the heads of drainageways. In some places they are on the top of extended ridges. Areas of this soil are generally 5 to 20 acres in size.

In some places this soil has a thinner surface layer than the one described as representative for the Armstrong series.

Included with this soil in mapping are eroded areas that have a lighter colored surface layer than this soil and in which the rest of the original surface layer and upper part of the subsoil are incorporated into the plow layer. Pebbles and gravel are common on the surface of this eroded soil. Also included in mapping are small areas of Armstrong soil that have slopes of 5 to 9 percent. Small severely eroded areas where the reddish-colored subsoil is exposed are shown on the map by a special symbol.

Runoff is medium or rapid on this soil, which is subject to erosion by runoff if the surface is not protected. This soil is often seepy in spring and tends to seal over if it is tilled when it is too wet. The surface then becomes hard and cloddy when it dries.

This soil is poorly suited to corn and soybeans. It is moderately suited to hay and is well suited to pasture. It is usually farmed with the adjacent soils. Capability unit IVe-2; woodland suitability group 5c1.

Boone Series

The Boone series consists of shallow, excessively drained soils that formed in material weathered from sandstone. These soils have convex slopes and are in uplands that border the larger valleys in the county. Slopes are 18 to 40 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam 5 inches thick. The subsurface layer is brown loamy fine sand 3 inches thick. The next layer, between depths of 8 and 14 inches, consists of yellowish-brown fine sand interbedded with soft and hard fragmented sandstone. The underlying material, between depths of 14 and 19 inches, consists of interbedded strata of weakly and strongly cemented sandstone and fine sand. It is brown, reddish brown, yellowish brown, or light brownish gray. Below this is weakly cemented sandstone.

Available water capacity is very low in these soils. Permeability is rapid. The surface layer is medium acid and is low in content of organic matter. The subsoil is low in available phosphorus and potassium.

Water erosion and soil blowing are serious hazards on these soils because of steep slopes and sandy texture. Boone soils are suited to pasture, trees, or wildlife habitat.

Representative profile of Boone fine sandy loam, 18 to 40 percent slopes, 400 feet south and 1,000 feet east of the NW. corner of the SE¼ sec. 16, T. 76 N., R. 16 W.:

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, brown (10YR 5/3) when dry; weak, fine, granular structure; very friable; soft when dry; common roots; medium acid; clear, smooth boundary.

A2—5 to 8 inches, brown (10YR 4/3) loamy fine sand, brown (10YR 5/3) when dry; weak, fine, granular structure; very friable; soft when dry; many roots; common, fine, hard sand fragments that are less than 1 inch in length and less than ¼ inch thick; strongly acid; clear, smooth boundary.

AC—8 to 14 inches, yellowish-brown (10YR 5/4) fine sand that has interbedded soft and hard fragmented sandstone, pale brown (10YR 6/3) when dry; structureless; very friable; many roots; few, hard sandstone fragments ½ to 2 inches in length and as much as ¼ inch thick; medium acid; clear, smooth boundary.

C—14 to 19 inches, mixed strong-brown (7.5YR 5/6), reddish-brown (5YR 4/4), and light brownish-gray (2.5Y 6/2) interbedded, strongly cemented, fractured sandstone and fine sand; very hard when dry; many hard sandstone fragments ½ to 1 inch thick and several inches in length; slightly acid; abrupt, irregular boundary.

R—29 to 26 inches, yellowish-brown (10YR 5/4), weakly cemented sandstone; hard when dry; few, thin, yellowish-red (5YR 4/6) iron-stained bands; medium acid.

The A1 horizon is very dark grayish brown (10YR 3/2) to brown (10YR 4/3), and the A2 horizon is dark grayish brown (10YR 4/2) to pale brown (10YR 6/3). The thickness of this soil over sandstone ranges from 6 to 20 inches. The fragments of sandstone may be hard or soft. They tend to be small and increase in number with depth but may range from few to many in the A1, A2, and C1 horizons.

Boone soils are associated with Chelsea and Sparta soils and formed in material similar to that of the Sogn soils. They are underlain by sandstone, while Sogn soils are underlain by limestone. They are unlike Chelsea and Sparta soils in that they are underlain by sandstone at a shallow depth.

The Boone soils in this county are shallower to sandstone than the typical soils of the Boone series, but these Boone soils are steep, and the soil interpretations are not significantly different.

Boone fine sandy loam, 18 to 40 percent slopes (210G).—This soil has convex slopes and is on the uplands bordering the larger valleys. Areas of this soil are long and narrow and have very irregular boundaries. They are generally 20 to 70 acres in size but may be more than 1 mile in length.

Included with this soil in mapping are sandstone and shale outcrops and eroded areas. Ledges or escarpments are common and are shown on the map by special symbols. These ledges, outcrops, and severely eroded areas make up less than 15 percent of the mapped areas. Also included are areas as much as 3 acres in size of Chelsea soils and of a soil similar to the one described but more than 20 inches deep to sandstone. These included soils make up less than 20 percent of the mapped areas.

Runoff is rapid on this soil during hard rains. The hazards of water erosion and soil blowing are severe if the surface is not protected by vegetation cover.

This soil is used for pasture, trees, and wildlife habitat. It is not suitable for crops. Capability unit VIIs-1; woodland suitability group 5s1.

Bremer Series

The Bremer series consists of deep, poorly drained soils that formed in clayey alluvium in the valleys of the larger streams. These soils are on low, smooth benches or flood plains. Slopes are 0 to 2 percent. The native vegetation was grass.

In a representative profile the surface layer is black silty clay loam 15 inches thick. The subsoil extends to a depth of 60 inches. The upper part is very dark gray heavy silty clay loam grading to silty clay with depth. Dark-brown and yellowish-brown mottles are below a depth of 25 inches. The lower part of the subsoil is dark-gray silty clay grading to gray light silty clay with depth. The underlying material is gray to light-gray heavy silty clay loam that has mottles of dark brown.

Available water capacity is high in these soils. Permeability is slow or moderately slow. The surface layer is high in content of organic matter. The subsoil is low in available phosphorus and potassium. Wetness is a hazard because of occasional overflow and a high water table in wet seasons. Fieldwork is often delayed. In a few places water tends to stand long enough to affect crops.

Bremer soils are well suited to row crops and hay if adequately drained and properly managed.

Representative profile of Bremer silty clay loam, 0 to 2 percent slopes, in a cultivated area 40 feet west and 1,090 feet south of the NE. corner of sec. 5, T. 74 N., R. 16 W.:

Ap—0 to 8 inches, black (10YR 2/1) medium silty clay loam; moderate, medium and fine, granular structure; firm; neutral; abrupt, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) silty clay loam; black (N 2/0) coatings on ped faces; weak, medium, subangular blocky structure that parts to moderate, fine, granular; firm; neutral; clear, smooth boundary.

B1t—15 to 25 inches, very dark gray (10YR 3/1) heavy silty clay loam; black (10YR 2/1) coatings on ped faces; moderate, fine, prismatic structure that parts to moderate, fine, subangular blocky; firm; nearly continuous organic coatings and clay films; few roots and tubular pores; slightly acid; gradual, smooth boundary.

B21tg—25 to 36 inches, very dark gray (10YR 3/1) silty clay; common, fine, faint mottles of dark brown (10YR 3/3) and yellowish brown (10YR 5/6); moderate, fine, prismatic structure that parts to moderate, fine, subangular blocky; firm; nearly continuous organic coatings and clay films; few roots and tubular pores; slightly acid; gradual, smooth boundary.

B22tg—36 to 49 inches, dark-gray (10YR 4/1) silty clay; common, fine, faint mottles of dark brown (10YR 3/3); moderate, fine, prismatic structure that parts to moderate, fine, subangular blocky; firm; nearly continuous organic and clay films; few roots and tubular pores; few, fine, soft, strong-brown (7.5YR 5/6) accumulations; neutral; gradual, smooth boundary.

B3g—49 to 60 inches, gray (10YR 5/1) light silty clay; common, fine, faint mottles of dark brown (10YR 3/3); firm; moderate, fine, subangular blocky structure; neutral; gradual, smooth boundary.

C1g—60 to 78 inches, gray (10YR 5/1) heavy silty clay loam; common, fine, faint mottles of dark brown (10YR 3/3); weak, fine, subangular blocky structure; firm; neutral; clear, wavy boundary.

C2g—78 to 100 inches, light-gray (10YR 6/1) heavy silty clay loam; many, fine, faint mottles of brown (10YR 4/3); weak, fine, subangular blocky structure; firm; few black oxides; neutral.

The A horizon is light silty clay loam to clay loam that ranges from 14 to 20 inches in thickness. It is black (10YR 2/1) or very dark gray (N 3/0). In the B horizon clay films range from few, thin, and discontinuous to continuous. The B2t horizon ranges from heavy silty clay loam to silty clay and is 16 to 24 inches in thickness. It is very dark gray or gray. Hue in the B2t horizon is 10YR, 2.5Y, or 5Y; value is 3 or 4; and chroma is 1. Depth to the C horizon ranges from 40 to 60 inches. This horizon is medium to heavy silty clay loam that is dark gray, gray, or light gray. Hue in the C horizon is 2.5Y or 5Y; value is 4 to 6; and chroma is 1.

Bremer soils are associated with Zook and Nevin soils. They have a color value of 3 or less to a shallower depth than Zook soils, and unlike Zook soils they have clay films in the B horizon. Mottles are higher in the profile in Bremer soils than in Zook soils. Bremer soils have grayer hues in the B horizon than Nevin soils, and unlike Nevin soils they have chromas of 1.

Bremer silty clay loam, 0 to 2 percent slopes (43).—This soil is on the smooth bottom lands of the Des Moines (fig. 9) and Skunk Rivers. Areas are generally longer than they are wide and are irregular in shape. They range from 15 to 50 acres in size, and they more or less parallel the river.

Included with this soil in mapping are small areas of Colo and Zook soils. Small wet areas that are less than 1 acre in size are shown on the soil map by a wet symbol.

Runoff is slow on this soil. The surface is occasionally

Figure 9.—**Typical area of Bremer silty clay loam, 0 to 2 percent slopes, on bottom land of Des Moines River.**

flooded, and the water table is high in spring. Puddles form readily on this soil, and the surface layer is cloddy and hard when dry. Compaction is a concern where this soil is worked when it is too wet. Both drainage ditches and tile drains are needed in places.

This soil is well suited to corn, soybeans, and hay if it is properly managed and adequately drained. Capability unit IIw-2; woodland suitability group 5w3.

Caleb Series

The Caleb series consists of deep, moderately well drained soils that formed in variable erosional sediment on dissected uplands. These soils abut drainageways and extend as far as the upper reaches. Slopes are convex and range from 9 to 25 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark grayish-brown loam 6 inches thick. The subsurface layer is brown sandy loam 5 inches thick. Gray silt coatings are on faces of peds (individual soil aggregates) in this layer. The subsoil, about 38 inches thick, is stratified brown loam in the upper part, and this part has dark grayish-brown clay films and gray silt coatings on faces of peds. The middle part of the subsoil is yellowish-brown sandy clay loam that has brown clay films on faces of peds, and the lower part is stratified yellowish-brown sandy clay loam and clay loam. The underlying material is yellowish-brown loamy fine sand that grades to loam at a depth of 49 to 66 inches. It is yellowish-brown fine sandy loam between depths of 66 and 75 inches and yellowish-brown gravelly loamy sand between depths of 75 and 81 inches.

Available water capacity is moderate in these soils. Permeability varies but is commonly moderate. The surface layer is generally medium acid, unless it has been limed, and is low to very low in content of organic matter. The subsoil is very low in available phosphorus and potassium.

Water erosion is a serious hazard on these soils because of slope. The strongly sloping Caleb soils are suited to crops, but areas of steeper Caleb soils are better suited to hay, pasture, trees, or wildlife habitat.

Representative profile of Caleb loam, 18 to 25 percent slopes, moderately eroded, in a pasture 290 feet west and 100 feet south of the NE. corner of NW¼ sec. 12, T. 74 N., R. 14 W.:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) when crushed and dry; weak, medium and fine, granular structure; friable; common roots; medium acid; abrupt, smooth boundary.

A2—6 to 11 inches, brown (10YR 4/3) sandy loam, dark brown (10YR 3/3) when kneaded, light brownish gray (10YR 6/2) when crushed and dry; weak, medium, subangular blocky structure; friable; common roots; common to many gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B1t—11 to 19 inches, brown (10YR 4/3) loam; dark brown (10YR 3/3) when kneaded, brownish yellow (10YR 6/6) when crushed and dry; moderate, medium and coarse, subangular blocky structure; friable; thin, discontinuous, dark grayish-brown (10YR 4/2) clay films; common gray silt coatings on ped faces; common pebbles; strongly acid; gradual, smooth boundary.

B21t—19 to 27 inches, yellowish-brown (10YR 5/4) sandy clay loam; strong, fine and medium, angular blocky structure; friable; thin, discontinuous, brown (7.5YR 4/4) clay films and iron stains; strongly acid; gradual, smooth boundary.

B22t—27 to 38 inches, yellowish-brown (10YR 5/6) sandy clay loam; moderate, medium, subangular blocky structure; friable; thin, continuous, brown (7.5YR 4/2) clay films; strongly acid; clear, smooth boundary.

B3t—38 to 49 inches, yellowish-brown (10YR 5/6), stratified sandy clay loam and clay loam; weak, coarse, subangular blocky structure; very friable; thick, discontinuous, brown (7.5YR 4/4) clay films; many gravel-size particles; very strongly acid; clear, smooth boundary.

C1—49 to 60 inches, yellowish-brown (10YR 5/4) loamy fine sand; single grained; loose; very strongly acid; clear, smooth boundary.

C2—60 to 66 inches, yellowish-brown (10YR 5/6) loam; weak, medium, subangular blocky structure; friable; brown (7.5YR 4/4) iron stains; some gravel; strongly acid; clear, smooth boundary.

C3—66 to 75 inches, yellowish-brown (10YR 5/6) fine sandy loam; single grained; loose; common gravel; very strongly acid; clear, smooth boundary.

C4—75 to 81 inches, yellowish-brown (10YR 5/6) gravelly loamy sand; single grained; loose; very strongly acid.

The A1 or Ap horizon is silt loam to loam or light clay loam that ranges from 6 to 9 inches in thickness. It is very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1). The A2 horizon is 2 to 7 inches thick, and it is dark grayish brown (10YR 4/2) to brown (10YR 5/3). Structure ranges from weak platy to weak subangular blocky, and texture is silt loam to loam or sandy loam. The B horizon is stratified and varies in thickness, color, and texture from place to place. It is typically loam, sandy clay loam, and clay loam. Depth to the C horizon is 42 to 72 inches.

Caleb soils are associated with Gara and Lindley soils. They have less clay in the B horizon than Gara and Lindley soils and, unlike these soils, have stratified B and C horizons.

Caleb loam, 9 to 14 percent slopes, moderately eroded (451D2).—This soil has convex slopes and is on dissected uplands. In some places it is along the upper part of hills near the upper end of drainageways, and in others it is on small foot slopes. Areas of this soil are long and narrow, have irregular boundaries, and are generally 5 to 10 acres in size.

Included with this soil in mapping are areas that have a surface layer 3 to 6 inches thick and a few areas where slopes are 5 to 9 percent. Also included are small areas that are severely eroded and areas where reddish, gravelly and clayey buried layers have been exposed and weathered. The areas of exposed buried layers are shown on the map by a special symbol.

Runoff is rapid on this soil. The hazard of water erosion is moderate. The surface layer is low in content of organic matter, and is friable. Tilth is good.

This soil is moderately suited to crops. It is well suited to hay, pasture, or trees. Capability unit IVe-3; woodland suitability group 2o1.

Caleb loam, 14 to 18 percent slopes, moderately eroded (451E2).—This soil has convex slopes and is on dissected uplands. In some places it is on hills along the sides and ends of drainageways. Areas of this soil are long and narrow, have irregular boundaries, and are generally 5 to 20 acres in size.

Included with this soil in mapping are areas that have a surface layer 3 to 6 inches thick. Also included are areas where reddish gravelly and clayey buried layers have been exposed and weathered and small areas of severely eroded soils. These areas are shown on the map by a special symbol.

Runoff is rapid on this soil. The hazard of water erosion is severe. The surface layer is low in content of organic matter and is friable. Tilth is good.

This soil is suitable for hay, pasture, trees, and wildlife habitat. Capability unit VIe-1; woodland suitability group 2o1.

Caleb loam, 18 to 25 percent slopes, moderately eroded (451F2).—This soil has convex slopes and is on dissected uplands. It is on hillsides along the sides and ends of drainageways. Areas of this soil are long and narrow, have irregular boundaries, and are generally 10 to 20 acres in size. This soil has the profile described as representative for the Caleb series.

Included with this soil in mapping are areas that have a surface layer 3 to 6 inches thick. Also included are small areas that are severely eroded. These are shown on the map by a special symbol.

Runoff is rapid on this soil. The hazard of water erosion is severe. The surface layer is low in content of organic matter.

This soil is suited to pasture, trees, or wildlife habitat. Capability unit VIIe-1; woodland suitability group 3r1.

Chelsea Series

The Chelsea soils are deep, excessively drained, sandy soils that formed in sand reworked by wind. These soils are on the eastern or southern side of the valley and on uplands adjacent to the Des Moines and North and South Skunk Rivers. Slopes are 4 to 25 percent. The native vegetation was trees.

In a representative profile the surface layer is brown loamy fine sand 18 inches thick. Below the surface layer is yellowish-brown loamy fine sand to a depth of 34 inches. Yellowish-brown fine sand is between depths of 34 to 43 inches. A few, thin, dark-brown to brown sandy loam bands are in the find sand between depths of 40 and 60 inches.

Available water capacity is low in these soils. Permeability is rapid. The surface layer is very low in content of organic matter. The subsoil is very low in available phosphorus and potassium.

The major hazards when using these soils for crops are droughtiness and erosion.

These soils are better suited to permanent pasture, Christmas tree or other tree growth, and wildlife habitat than to other uses.

Representative profile of Chelsea loamy fine sand, 4 to 9 percent slopes, in idle land 170 feet east and 160 feet south of the NW. corner of NE¼NW¼ sec. 25, T. 74 N., R. 16 W.:

Ap—0 to 10 inches, brown (10YR 4/3) loamy fine sand, light gray (10YR 7/2) when dry; weak, medium, granular structure that parts to single grained; loose; slightly acid; abrupt, smooth boundary.

AC—10 to 18 inches, brown (10YR 4/3) loamy fine sand; massive to single grained; loose; strongly acid; clear, smooth boundary.

C1—18 to 34 inches, yellowish-brown (10YR 5/4) loamy fine sand, white (10YR 8/2) when dry; single grained; loose; strongly acid; gradual, smooth boundary.

C1 & B—34 to 43 inches, yellowish-brown (10YR 5/4) fine sand; single grained; loose; thin, dark-brown (10YR 3/3) light sandy loam band at a depth of 42 inches; strongly acid; diffuse, smooth boundary.

C2 & B—43 to 62 inches, mixed yellowish-brown (10YR 5/4), light yellowish-brown (10YR 6/4), brown (7.5YR 4/4), and reddish-brown (5YR 4/4) fine sand; thin brown (10YR 4/3) band of light sandy loam at a depth of 56 inches; single grained; loose; strongly acid.

The A1 horizon, where it is not eroded, ranges from 2 to 6 inches in thickness. It is very dark grayish brown (10YR 3/2), dark grayish brown (10YR 4/2), or brown (10YR 4/3). The A2 horizon is often incorporated into the Ap horizon and not discernible. The B horizon has lamellae ¼ to 2 inches thick that have a hue of 7.5R or 10R, value and chroma of 3 or 4, and texture of light sandy loam or loamy sand. Depth to the uppermost lamella is generally about 3 feet and ranges from 27 to 48 inches. Total thickness of the lamellae at a depth above 60 inches is less than 6 inches. The B horizon is strongly acid to medium acid. The C1 horizon is loamy fine sand or fine sand. It is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). The C2 horizon is light yellowish brown (10YR 6/4) or yellowish brown (10YR 5/4).

Chelsea soils formed in material similar to that of the parent material of Sparta soils. They have a lighter colored and thinner A horizon than Sparta soils. Also, in most places Chelsea soils are more acid throughout their solum than Sparta soils.

Chelsea loamy fine sand, 4 to 9 percent slopes (63C).—This soil is on convex upland ridgetops and side slopes adjacent to the Des Moines and Skunk Rivers or their tributaries. It is generally upslope from Chelsea soils that are strongly sloping to steep. Slopes are often irregular and complex. The areas of this soil are irregular in shape and 10 to 30 acres in size. This soil has the profile described as representative for the Chelsea series.

Included with this soil in mapping are small areas of Clinton, Ladoga, and Fayette soils.

Runoff is medium during hard rains on this soil. The hazards of water erosion and soil blowing are severe.

This soil is suited to pasture but it is droughty. It is poorly suited to commonly grown crops. Rye is often used as a winter cover crop. In places this soil is used to grow Christmas trees. Capability unit IVs-1; woodland suitability group 4s1.

Chelsea loamy fine sand, 9 to 14 percent slopes, moderately eroded (63D2).—This soil is on short, convex side slopes adjacent to the Des Moines and Skunk Rivers or their tributaries. It is associated with areas of moderately steep and steep Chelsea soils. Areas are irregular in shape and 10 to 30 acres in size.

This soil has a profile similar to that described as representative for the Chelsea series, but the surface layer is thinner.

Included with this soil in mapping in places are small areas of Clinton, Ladoga, or Fayette soils that are 2 or 3 acres in size. In a few areas that are wooded, about 1½ inches of leaf litter is on the surface and the surface layer is thin and very dark grayish brown.

Runoff is medium during hard rains. The hazards of water erosion and soil blowing are very severe. The areas that are severely eroded are shown on the map by a special symbol.

This soil is droughty, and consequently the acreage cultivated is not large. This soil is suited to pasture, trees, or

wildlife habitat. Capability unit VIs-1; woodland suitability group 4s1.

Chelsea loamy fine sand, 14 to 18 percent slopes, moderately eroded (63E2).—This soil has short, convex slopes and is adjacent to the Des Moines and Skunk Rivers or their tributaries. Areas are elongated and are generally 15 to 40 acres in size.

This soil has a profile similar to that described as representative for the Chelsea series, but the surface layer is thinner.

Included with this soil in mapping are areas of wooded soils that have been protected from overgrazing and have about 1½ inches of leaf litter on the surface. In these areas the surface layer is thin and very dark grayish-brown. Areas that are severely eroded and that have a yellowish-brown surface layer are also included and are shown on the map by special symbols. Areas of Clinton, Fayette, or Lindley soils, 2 or 3 acres in size, are included along the Skunk River.

Runoff is rapid during hard rains. The hazard of water erosion and soil blowing are severe.

This soil is low in available plant nutrients and very droughty. Many areas of this soil are too steep to be renovated with regular farm machinery, and for this reason pasture plants do not grow well. This soil is suitable for trees or wildlife habitat. Capability unit VIs-1; woodland suitability group 4s1.

Chelsea loamy fine sand, 18 to 25 percent slopes, moderately eroded (63F2).—This soil is on the lower part of slopes adjacent to the Des Moines and Skunk Rivers. Areas of it are elongated and are generally 10 to 30 acres in size.

This soil has a profile similar to that described as representative for the series, but the surface layer is thinner.

Included with this soil in mapping are severely eroded areas. These are shown on the map by a special symbol. Also small areas up to 2 acres in size of Clinton, Fayette, or Lindley soils are included with this soil in places.

Runoff is rapid on this soil. The hazards of water erosion and soil blowing are severe.

This soil is suited to limited use for pasture, trees, or wildlife habitat. Because of the slope, tree planting and wood removal are difficult. Capability unit VIIs-2; woodland suitability group 4s1.

Chelsea-Clinton complex, 5 to 9 percent slopes, moderately eroded (293C2).—This complex is on convex or rolling uplands. It is mainly on the east or south side of the valley of the larger streams in the county. Slopes are short. The areas are irregular in shape and are generally 10 to 40 acres in size. Chelsea soil generally has more convex slopes and is in areas that are oval or elongated and have the longer axis oriented from northwest to southeast. It makes up about 30 to 40 percent of the complex and is surrounded by Clinton soil, which also makes up about 30 to 40 percent of the complex.

Included with this soil in mapping are small severely eroded areas of Chelsea soil or of glacial till. These areas are shown on the map by a special symbol. Also included are small areas of Fayette, Downs, and Seaton soils.

Runoff is moderate on soils of this complex. The hazards of water erosion and soil blowing are moderate to severe. The surface layer is friable or very friable and is easy to till. The sandy areas are droughty.

This complex is moderately suited to corn and soybeans. It is well suited to hay or pasture. Capability unit IVs-1; woodland suitability group 4s1.

Chelsea-Clinton complex, 9 to 14 percent slopes, moderately eroded (293D2).—This complex is on rolling uplands and in areas on uplands where slopes are convex. It is mainly on the east or south sides of the valleys of the larger streams in the county. Slopes are relatively short in length. Areas are generally elongated and irregular and 10 to 40 acres in size. Chelsea soil generally has convex slopes and is in areas where the longer axis is oriented from northwest to southeast. It makes up about 30 to 40 percent of the complex and is surrounded by Clinton soil, which also makes up about 30 to 40 percent of the complex.

Included with these soils in mapping are small severely eroded areas of Chelsea soil or glacial till. These are shown on the map by a special symbol. Also included are small areas of Fayette, Downs, and Seaton soils.

Runoff is rapid on soils of this complex. The hazards of water erosion and soil blowing are severe. The surface layer is friable or very friable and is easy to till. The sandy areas are droughty.

This complex is rather poorly suited to corn and soybeans. It is well suited to hay or pasture. Capability unit IVe-5; woodland suitability group 4s1.

Chelsea-Clinton complex, 14 to 18 percent slopes, moderately eroded (293E2).—This complex is on rolling uplands and in areas on uplands where slopes are convex. It is mainly on the east or south sides of the valleys of the larger streams in the county. Slopes are relatively short. Areas are generally elongated and irregular in shape and 10 to 40 acres in size. Chelsea soil generally has convex slopes and is in areas where the longer axis is oriented from northwest to southeast. It makes up about 30 to 40 percent of the complex and is surrounded by Clinton soil, which also makes up about 30 to 40 percent of the complex.

Included with these soils in mapping are small, severely eroded areas of Chelsea soil or glacial till. These are shown on the map by a special symbol. Also included are small areas of Fayette, Downs, and Seaton soils.

Runoff is rapid on soils of this complex. The hazards of water erosion and soil blowing are severe. The surface layer is friable or very friable and is easy to till. The sandy areas are droughty.

This complex is poorly suited to corn and soybeans. It is well suited to hay or pasture. Capability unit VIs-1; woodland suitability group 4s1.

Clarinda Series

The Clarinda series consists of deep, poorly drained soils on uplands. They formed in clayey, grayish glacial till called "gumbotil." Gumbotil was the subsoil of a soil that once was at the surface of the nearly level Kansan drift plain. Later a deposit of loess covered the gumbotil, but geologic erosion has removed the loess in many places and has exposed the gumbotil. The upper boundary of these soils is at the loess-till contact line. Areas are narrow and are on short, convex side slopes and at the heads of drainageways. Slopes are 5 to 14 percent. The native vegetation was grass.

In a representative profile the surface layer is black light silty clay loam 12 inches thick. The clay subsoil is gleyed and extends to a depth of 96 inches. It is dark gray and dark grayish brown and has mottles of strong brown between depths of 12 and 20 inches, gray with mottles of dark brown and light olive brown and clay films between depths of 20 and 53 inches, and gray with mottles of dark yellowish brown and dark brown between depths of 53 and 96 inches.

Available water capacity is high in these soils. Permeability is very slow. The surface layer is typically strongly acid unless it has been limed, and it ranges from low to high in content of organic matter. The subsoil is low in available phosphorus and low to medium in available potassium.

Clarinda soils are poorly suited to row crops and are better suited to pasture.

Representative profile of Clarinda silty clay loam, 5 to 9 percent slopes, in a pasture 180 feet west and 780 feet south of the NE. corner of NE¼ sec. 33, T. 74 N., R. 14 W.:

A1—0 to 12 inches, black (10YR 2/1) light silty clay loam; moderate, medium, granular structure; friable; common roots; strongly acid; clear, smooth boundary.

IIB1tg—12 to 20 inches, 75 percent dark gray (10YR 4/1) and 25 percent dark grayish-brown (10YR 4/2) clay; common, fine, distinct mottles of strong brown (7.5YR 5/6); moderate, fine, subangular blocky structure; very firm; thick, continuous clay films; strongly acid; gradual, smooth boundary.

IIB2tg—20 to 53 inches, gray (5Y 5/1) clay; few, fine, prominent, dark-brown (7.5YR 4/4) mottles; few, fine, distinct mottles of light olive brown (2.5Y 5/6); weak, medium, subangular blocky structure; thick, continuous clay films; very firm; common, fine, white sand grains; medium acid in the upper part and neutral in the lower part; gradual, smooth boundary.

IIB3g—53 to 96 inches, gray (5Y 6/1) clay; few, medium, prominent mottles of dark yellowish brown (10YR 4/4) and dark brown (7.5YR 3/2); weak, medium, prismatic structure that parts to weak, medium, subangular blocky; very firm; common pebbles; common white sand grains; neutral.

The A horizon is heavy silt loam to silty clay loam that ranges from 10 to 15 inches in thickness where it is not eroded. It is black (10YR 2/1) to very dark gray (10YR 3/1). The IIB2tg horizon has a hue of 2.5Y or 5Y and a value of 4 or 5. Chroma is dominantly 1. This horizon is typically clay but in places is silty clay. The depth to the C horizon is generally more than 90 inches.

Clarinda soils are associated with Armstrong and Lamoni soils. Clarinda soils have a thicker A1 horizon and are grayer than Armstrong soils. They have more clay and less sand and gravel in the B horizon than Armstrong and Lamoni soils.

Clarinda silty clay loam, 5 to 9 percent slopes (222C).—This soil has convex slopes and is on uplands just below the loess-till contact line, or "seep line." This soil is in coves at the heads of drainageways in crescent-shaped areas. It is also in long and narrow areas that are irregular in shape. Areas are generally 5 to 20 acres in size. This soil has the profile described as representative for the Clarinda series.

Included with these soils in mapping are small areas of Clearfield soil.

Runoff is medium on this soil. The hazard of water erosion is moderate. This soil is often wet in spring and is difficult to farm because it is sticky when it is wet and hard and cloddy when it is dry.

This soil is generally used for but is poorly suited to corn and soybeans. It is in small areas adjacent to more productive soils and is generally farmed along with them. It is better suited to hay or pasture than to other uses. Capability unit IIIe-4; woodland suitability group 5w1.

Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded (222C2).—This soil has convex slopes and is on uplands. It is just below the loess-till contact line and runs on the contour around hill slopes and into coves at the heads of drainageways. In a few places it is on the top of slightly extended ridges. Areas are rather long and narrow, have irregular boundaries, and are generally 10 to 20 acres in size.

This soil has a profile similar to that described as representative for the Clarinda series, but the surface layer is thinner.

Included with this soil in mapping are small areas of severely eroded Clarinda soil. These are shown on the map by special symbols.

Runoff is medium to rapid on this soil. The hazard of water erosion is moderate. The soil is often seepy and sticky in spring. The surface tends to seal over if it is tilled when it is too wet and then becomes hard and cloddy when dry.

This soil is generally used for corn and soybeans because it is in small areas adjacent to more productive soils though poorly suited to these crops. It is better suited to hay or pasture. Capability unit IIIe-4; woodland suitability group 5w1.

Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded (222D2).—This soil has convex slopes and is on uplands. It is just below the loess-till contact line and runs on the contour along hill slopes and into coves at the heads of drainageways. Areas are generally long and narrow, have irregular boundaries, and are generally 10 to 20 acres in size.

This soil has a profile similar to that described as representative for the Clarinda series, but the surface layer is thinner.

Included with this soil in mapping are small areas of severely eroded Clarinda soil. These are shown on the maps by a special symbol.

Runoff is rapid on this soil. The hazard of erosion is severe. This soil is often seepy and sticky in spring. The surface becomes hard and cloddy when dry. This is a difficult soil to farm.

This soil is in small areas adjacent to more productive soils, so it is generally used for row crops. It is poorly suited to corn and soybeans. It is better suited to hay, meadow, or pasture. Capability unit IVe-2; woodland suitability group 5w1.

Clearfield Series

The Clearfield series consists of deep, poorly drained or somewhat poorly drained soils in uplands. They formed in 3 to 5 feet of loess that is underlain by clay. These soils are seepy and are in coves around the heads of drainageways in small areas downslope from the gently sloping divides. Slopes are 5 to 9 percent. The native vegetation was grass.

In a representative profile the surface layer is about 10 inches of black light silty clay loam. Below this is very dark gray silty clay loam. The subsoil is dark-gray silty clay loam between depths of 15 and 29 inches and mottled, grayish-brown and light olive-brown silty clay loam between depths of 29 and 36 inches. It is light-gray medium silty clay loam below that depth. Yellowish-brown and strong-brown mottles are common in the subsoil. Light-gray and yellowish-brown clay that is high in content of sand is at a depth of about 54 inches.

Available water capacity is high in these soils. Permeability is moderately slow in the upper 4½ feet and very slow in the underlying clay layer. These soils are normally wet and seepy in both the surface layer and subsoil because drainage water from the more permeable loess moves laterally over the compact, very slowly permeable underlying clay layer. Wetness restricts root growth in most areas. The surface layer is high in content of organic matter. The subsoil is low in available phosphorus and potassium.

Where the wetness is corrected, these soils are used for and suited to row crops, but they are subject to erosion.

Representative profile of Clearfield silty clay loam, 5 to 9 percent slopes, 486 feet south and 162 feet west of the NE. corner of the SW¼NE¼ sec. 33, T. 76 N., R, 16.:

Ap—0 to 10 inches, black (10YR 2/1) light silty clay loam; very dark grayish brown (10YR 3/2) when dry; moderate, fine and medium, granular structure; friable; neutral; clear, smooth boundary.

A3—10 to 15 inches, very dark gray (10YR 3/1) silty clay loam; grayish brown (10YR 5/2) when dry; common, fine, prominent mottles of yellowish brown (10YR 5/4); moderate, fine, soft oxides of brown (7.5YR 4/4) and black (10YR 2/1); neutral; clear, smooth boundary.

B1t—15 to 22 inches, dark-gray (2.5Y 4/1) silty clay loam; few, fine, faint mottles of yellowish brown (10YR 5/6); dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) coatings on ped faces; moderate, fine and medium, subangular blocky structure; friable; thin, discontinuous clay films; few, fine, soft oxides of dark brown and black; neutral; clear, smooth boundary.

B21tg—22 to 29 inches, dark-gray (10YR 4/1) silty clay loam; many, fine, faint mottles of yellowish brown (10YR 5/4) and grayish brown (10YR 5/2); very dark gray (10YR 3/1) and dark gray (10YR 4/1) coatings on ped faces; moderate, medium and fine, subangular blocky structure; friable; thin, discontinuous clay films; few soft black oxides; neutral; gradual, smooth boundary.

B22tg—29 to 36 inches, mottled, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) silty clay loam; common, fine, distinct mottles of light olive brown (2.5Y 5/6) and strong brown (7.5Y 5/6); very dark gray (10YR 3/1) and dark gray (10YR 4/1) coatings on ped faces; moderate, medium, subangular blocky structure; friable; thin, discontinuous clay films; neutral; gradual, smooth boundary.

B3g—36 to 54 inches, light-gray (10YR 6/1) medium silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to weak, coarse, subangular blocky; firm; common, fine, soft oxides of black (10YR 2/1) and strong brown (7.5YR 5/6); neutral; clear, smooth boundary.

IIBb—54 to 66 inches, mottled, light-gray (10YR 6/1) and yellowish-brown (10YR 5/4) clay; high in content of sand; very firm; common, fine, soft oxides of strong brown (7.5YR 5/6); neutral.

The A horizon, where uneroded, is typically 10 to 20 inches in thickness. It is black (10YR 2/1 or N 2/0). Content of clay ranges from 27 to 35 percent. The B2t horizon has a hue of 10YR or 2.5Y in the upper part and mottles of grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) to gray (N 5/0, 2.5Y 5/1, or 2.5Y 6/1) or light brownish gray (2.5Y 6/2) in the lower part. Content of clay ranges from 32 to 35 percent. The depth to that is 40 to 50 percent clay ranges from 3 to 5 feet. This clayey material has mottles of light gray (10YR 6/1) and yellowish brown (10YR 5/4) to very dark gray (10YR 3/1) and gray (10YR 5/1).

Clearfield soils are associated with Mahaska, Nira, and Otley soils. They are grayer in the B2t horizon and more poorly drained than Otley and Nira soils. Clearfield soils are steeper and are more poorly drained than the Mahaska soils.

Clearfield silty clay loam, 5 to 9 percent slopes (69C).—This soil is in coves around the heads of waterways and on rounded areas between waterways. Areas are 5 to 12 acres in size and are generally semicircular in shape.

This soil has the profile described as representative for the series. In some places the surface layer is black and as much as 20 inches thick.

Included with this soil in mapping are small areas of Nira soil and small spots of Clarinda soil. The spots of Clarinda soils are shown on the map by a special symbol.

Most of this soil is suited to crops. The major management concerns are wetness and seepiness. Also, moderate slopes and runoff make the soil subject to erosion. Waterways, which are very wet, are in areas of this soil. They tend to gully easily near the junction of the Clarinda soil and other soils downslope.

If wetness is corrected and erosion is controlled, this soil is moderately well suited to corn, soybeans, and other adapted crops. Areas are often small, so management of this soil also includes management of the adjacent Otley, Nira, and Mahaska soils. Capability unit IIIw-3; woodland suitability group 5w3.

Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded (69C2).—This soil is in coves around heads of upland drainageways that break abruptly from the broad upland divides. It is normally adjacent to moderately eroded Otley and Nira soils, which are on the rounded side slopes between the drainageways. Areas are generally 5 to 12 acres in size and semicircular in shape.

This soil has a profile similar to the one described as representative for the series, but the surface layer is thinner. In more eroded areas the plow layer is a mixture of the original surface layer and the subsoil.

Included with this soil in mapping are small areas that are less eroded than this soil and small areas of Otley, Mahaska, and Nira soils. Also included are small spots of Clarinda soils near the lower boundary. These are shown on the map by a special symbol.

The subsoil is wet and seepy unless drain tiles are installed. The surface layer in some areas is difficult to work, because subsoil material has been mixed in plowing, and tilling it when wet tends to make it cloddy. Areas are small, and most are managed along with adjacent soils.

If wetness is corrected and erosion is controlled, this soil is moderately well suited to corn, soybeans, and other adapted crops. Capability unit IIIw-3; woodland suitability group 5w3.

Clinton Series

The Clinton series consists of deep, moderately well drained soils that formed in loess on uplands. These soils have gentle to moderately steep, convex slopes and are usually on ridges and above glacial till or shale. In some places they are above limestone or sandstone or on benches in the valleys of some of the larger streams in the county. Slopes are 2 to 18 percent. The native vegetation was trees.

In a representative profile the surface layer is very dark grayish-brown silt loam 5 inches thick. The subsurface layer is brown silt loam 7 inches thick. The subsoil extends to a depth of more than 60 inches. It is dark yellowish-brown light silty clay loam in the upper part, dark yellowish-brown silty clay loam and brown heavy silty clay loam in the middle, and yellowish-brown silty clay loam that has grayish-brown mottles in the lower part.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is low in content of organic matter. The subsoil is high in available phosphorus and very low in available potassium.

Most areas of these soils are used for cultivated crops, but some areas are in pasture or trees, especially those areas on narrow ridges. Clinton soils are well suited to moderately well suited to row crops.

Representative profile of Clinton silt loam, 5 to 9 percent slopes, in a wooded area 550 feet east and 520 feet north of the SW. corner of NW¼SW¼ sec. 3, T. 74 N., R. 16 W.:

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A2—5 to 12 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) when dry; weak, fine and medium, platy structure; friable; strongly acid; clear, smooth boundary.

B1—12 to 15 inches, dark yellowish-brown (10YR 4/4) light silty clay loam, light yellowish brown (10YR 6/4) when dry; moderate, fine, subangular and angular blocky structure; friable; continuous gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B21—15 to 26 inches, dark yellowish-brown (10YR 4/4) silty clay loam; strong, fine and medium, subangular and angular blocky structure; friable; many gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B22t—26 to 34 inches, brown (10YR 4/3) heavy silty clay loam; moderate, medium and fine, subangular blocky structure; friable; thick, discontinuous clay films; medium acid; gradual, smooth boundary.

B23t—34 to 45 inches, yellowish-brown (10YR 5/4) silty clay loam; few, fine, prominent mottles of strong brown (7.5YR 5/6) and grayish brown (2.5Y 5/2); moderate, medium, blocky and subangular blocky structure; friable; thin, discontinuous clay films; few, fine dark oxides; strongly acid; gradual, smooth boundary.

B3—45 to 60 inches, yellowish-brown (10YR 5/4) medium silty clay loam; common, medium, prominent mottles of yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2); weak, coarse, prismatic structure parting to weak, medium, subangular blocky; friable; thin, discontinuous, brown (10YR 4/3) clay films; medium acid.

The A1 horizon, if uneroded, ranges from 3 to 5 inches in thickness. It is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The A2 horizon is dark grayish brown (10YR 4/2), brown (10YR 5/3), and grayish brown (10YR 5/2). It ranges from 6 to 10 inches in thickness. Cultivated and eroded areas have a dark grayish-brown (10YR 4/2) or brown (10YR 4/3) Ap horizon. The B2t horizon ranges from 24 to 36 inches in thickness. The B2t horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) and is 36 to 42 percent clay in the finest part. Clay films range from thin to thick and are continuous in the B2t horizon. The B3 horizon and the upper part of the C horizon are brown (10YR 5/3) or yellowish brown (10YR 5/4). Grayish-brown to olive-gray mottles are in the lower part of the B23t horizon and increase in size and number as depth increases. Depth to the C horizon ranges from 42 to 84 inches.

Clinton soils formed in material similar to that in which Ladoga, Otley, and Weller soils formed. They are associated with Ladoga and Weller soils. Clinton soils have less clay in the B horizon than Weller soils. They have a thinner or lighter colored A horizon than Ladoga and Otley soils.

Clinton silt loam, 2 to 5 percent slopes (80B).—This soil has narrow, convex slopes and is on upland divides and on the upper part of side slopes. Areas of this soil are usually long and narrow, have irregular boundaries, and are generally more than ½ mile in length and 10 to 30 acres in size.

Where this soil is cultivated, the surface layer is mixed with the subsurface layer, and the plow layer is lighter in color.

Included with this soil in mapping are small, nearly level areas that have surface and subsurface layers of silt loam 12 to 18 inches thick. Also included, at the heads of drainageways, are small areas that have a mottled subsoil and are not as well drained as this soil. In some places small sandy areas of Chelsea soils, indicated on the map by a sand spot symbol, are also included. These included soils make up to 20 percent of the mapping unit.

Runoff is medium on this soil. The surface layer is friable and easy to till. The hazard of erosion by runoff water is moderate.

Most areas of this soil are used for crops. It is well suited to corn, soybeans, and hay. Some areas are used for pasture or trees. Capability unit IIe-1; woodland suitability group 1o1.

Clinton silt loam, 5 to 9 percent slopes (80C).—This soil has convex slopes and is on ridgetops, narrow divides, and side slopes. The ridges usually extend back to wider, less sloping divides occupied by other Clinton soils or Ladoga soils. This soil often is upslope from more steeply sloping Clinton soils or soils that formed in glacial till or shale. Areas of this soil are quite long, narrow, and irregular in shape and are generally 5 to 20 acres in size. This soil has the profile described as representative for the Clinton series.

Included with this soil in mapping are some small areas of strongly sloping and more eroded Clinton soils. The lower part of some of the mapped areas includes very small areas of soils that have clayey reddish weathered till at or near the surface. In some places small areas of Chelsea soils, indicated on the map by a sand spot symbol, are also included.

Runoff is rapid on this soil. The surface layer is friable and easy to till. The hazard of erosion is severe unless this soil is properly managed.

This soil is moderately well suited to hay, corn, and soybeans if it is properly managed. It is well suited to pasture or trees. Capability unit IIIe-1; woodland suitability group 1o1.

Clinton silt loam, 5 to 9 percent slopes, moderately eroded (80C2).—This soil has convex slopes and is on ridgetops, narrow divides, and side slopes. The ridges usually extend from wider, less sloping areas of Clinton or Ladoga soils. This soil is generally upslope from more steeply sloping areas of Clinton soils or from soils that formed in glacial till or shale. Areas of this soil are quite long, narrow, and irregular in shape and are generally 10 to 30 acres in size.

This soil has a profile similar to the one described as representative for the Clinton series, but the eroded surface and subsurface layers are less than 7 inches thick and are dark grayish brown or brown. The surface layer is light silty clay loam in some places.

Included with this soil in mapping are small severely eroded soils that have weathered reddish clay at or near the surface and some sandy areas. These areas are shown on the map by special symbols. At the heads of drainageways some areas have a mottled subsoil and are not as well drained.

Runoff is rapid on this soil. The hazard of erosion is severe unless this soil is properly managed. The surface layer is friable. Tilth is poor. This soil is often cloddy and hard when dry and sticky when wet.

This soil is moderately well suited to hay, corn, and soybeans if it is properly managed. It is well suited to pasture or trees. Capability unit IIIe-1; woodland suitability group 1o1.

Clinton silt loam, 9 to 14 percent slopes, moderately eroded (80D2).—This soil is usually in bands around strongly sloping side slopes but in some places is on the crests of narrow ridges. It is generally downslope from less sloping Clinton soils, and in many places it is upslope from bottom lands. It is upslope from moderately steep and steep Lindley or Gosport soils. Areas of this soil are long, narrow, and irregular in shape and are generally 10 to 30 acres in size.

This soil has a profile similar to that described as representative of the series, but the surface layer and subsurface layer of this soil are mixed and are less than 7 inches thick and dark grayish brown or brown. The surface layer is light silty clay loam in some places.

Included with this soil in mapping are some small areas of moderately steep Clinton soils. Small areas of severely eroded soils that have reddish weathered clay at or near the surface and sandy Chelsea soils are also included and are

shown on the map by special symbols. In the extreme southwestern part of the county a few areas of Weller soil that has a more clayey subsoil than this soil are included.

Runoff is rapid on this soil during hard rains. The hazard of erosion is severe.

This soil is moderately well suited to corn, soybeans, and hay. It is well suited to pasture or trees. Many individual areas of this soil are small and are cultivated along with less sloping Clinton soil. Often this soil is used along with less suitable soils for pasture. Capability unit IIIe-2; woodland suitability group 1o1.

Clinton soils, 9 to 14 percent slopes, severely eroded (80D3).—These soils usually are in bands around strongly sloping side slopes. They are generally downslope from less sloping Clinton soils. They are upslope in many places from bottom lands. They also are upslope from moderately steep and steep Lindley or Gosport soils. Areas of these soils are long, narrow, and irregular in shape and are 5 to 15 acres in size.

These soils have a profile similar to that described as representative for the series, but only traces of the surface layer and subsurface layer of silt loam remain. The present surface layer or plow layer is light silty clay loam or heavy silt loam in most places and is brown to dark yellowish brown.

Included with these soils in mapping are some areas of moderately steep Clinton soils. Small areas of soils that have reddish clay at or near the surface and sandy Chelsea soils are included in mapping and are shown on the map by special symbols.

Runoff is rapid on these soils. Poor tilth and cloddiness result from the severe erosion that has removed practically all of the organic matter and exposed the less friable subsoil.

This soil is poorly suited to corn and soybeans. Areas of this soil are generally used for meadow or pasture. Waterways are usually present, and rapid concentration of water creates gullies, some uncrossable by farm machinery. Capability unit IVe-1; woodland suitability group 1o1.

Clinton silt loam, 14 to 18 percent slopes, moderately eroded (80E2).—This soil is moderately steep and is on upland side slopes. It generally is downslope from moderately sloping or strongly sloping Clinton soils and upslope from Lindley or Gosport soils or upslope from soils on bottom land or foot slopes. Areas of this soil are long, narrow, and irregular in shape and are 10 to 20 acres in size.

This soil has a profile similar to that described as representative for the series, but it has a mixed surface and subsurface layer less than 7 inches thick and is dark grayish brown or brown. This layer is light silty clay loam in some places.

Included with this soil in mapping are a few areas of Ladoga soil that has a darker colored surface layer than this soil. Also included are small areas of soil that is severely eroded and small areas of uneroded soil that has a thicker surface layer and a thicker subsurface layer than this soil. Small areas of soils that have reddish clay at or near the surface and areas of sandy Chelsea soils are also included and are shown on the map by special symbols.

Runoff is rapid on this soil during hard rains. The hazard of erosion is severe. The surface layer is friable. Tilth is poor, and the soil is often cloddy and hard when dry and sticky when wet.

This soil is moderately well suited to corn but is better suited to hay or improved permanent pasture. Capability unit IVe-1; woodland suitability group 1o1.

Colo Series

The Colo series consists of deep, poorly drained soils that formed in silty alluvium. These soils are nearly level and are on bottom lands along the major streams and their tributaries, on alluvial fans at the base of some upland slopes, and in nearly level upland drainageways. Slopes are as much as 5 percent but most are 2 percent or less. The native vegetation was prairie grasses that tolerate excessive wetness.

In a representative profile the upper 58 inches is black. It is light silty clay loam in the upper part and medium silty clay loam in the lower part. The underlying material is gray light silty clay loam that grades with depth to olive-gray loam. Below a depth of 68 inches are common brownish-yellow mottles and some strata of heavy clay loam.

Available water capacity is high in these soils. Permeability is moderately slow. These soils are subject to overflow, but water does not stand for long periods and the soils dry out readily. Most areas of Colo soils need tile drainage in meandering surface drains and small ponded areas. The surface layer is high in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium.

Colo soils are well suited to row crops, and are generally used for crops along with other adjacent bottom land soils.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, in a pasture 156 feet west and 87 feet north of the NE. corner of the SW¼NW¼ sec. 29, T. 74 N., R. 14 W.:

A11—0 to 8 inches, black (10YR 2/1) light silty clay loam; moderate, medium, granular structure; friable; neutral; clear, smooth boundary.

A12—8 to 27 inches, black (10YR 2/1) light silty clay loam; weak, medium and fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A13—27 to 33 inches, black (10YR 2/1) light silty clay loam; weak, medium, prismatic structure parting to weak, medium, subangular blocky; firm; neutral; gradual, smooth boundary.

AC—33 to 58 inches, black (10YR 2/1) medium silty clay loam; weak, medium, prismatic structure parting to weak, medium, subangular blocky; firm; neutral; gradual, smooth boundary.

C1g—58 to 68 inches, gray (5Y 5/1) light silty clay loam; moderate, medium, prismatic structure; firm; thin organic stains on vertical ped faces; neutral; gradual, smooth boundary.

C2g—68 to 87 inches, olive-gray (5Y 5/2) loam; common, medium, prominent brownish-yellow (10YR 6/6) mottles; firm; strata of heavy clay loam; neutral.

The upper part of the A horizon typically is black (N 2/0 or 10YR 2/1). Some Colo soils have stratified silt loam to light silty clay loam overwash that ranges in thickness from 7 to 18 inches and in color from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). The lower part of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The upper part of the A horizon is mostly light silty clay loam but ranges to silt loam, and the lower part ranges from light silty clay loam to medium silty clay loam. The C horizon has chroma of 0 and 1. Below a depth of 4 feet, the C horizon ranges from silty clay loam or loam to sandy or gravelly material, but the content of clay is typically 32 to 35 percent.

Colo soils are associated with Kennebec and Zook soils. They are more permeable and less clayey than Zook soils. They are grayer and more mottled in the upper 40 inches, are finer textured, and are more poorly drained than Kennebec soils.

Colo silt loam, overwash, 0 to 2 percent slopes (133+).—This soil is on the bottom lands of the larger streams or their tributaries. Areas are irregular in shape and are generally 10 to more than 40 acres in size.

This soil has a profile similar to that described as repre-

sentative for the Colo series, but the surface layer is very dark grayish-brown or grayish-brown stratified silt loam 7 to 18 inches thick.

Included with this soil in mapping are small areas of Colo silty clay loam and Kennebec silt loam.

Runoff is slow on this soil. The hazard of erosion caused by overflow water is not as serious a threat to young plants as is the accumulation of sediment on the surface. The surface layer is friable. Tilth is good, but farming operations are delayed in some places because of wetness.

If it is properly managed, this soil is well suited to corn, soybeans, and hay. Capability unit IIw-2; woodland suitability group 5w3.

Colo silty clay loam, 0 to 2 percent slopes (133).—This soil is on the bottom lands of the larger streams and their tributaries throughout the county. This is often the dominant soil along small streams in valleys that are 1/8 to 1/4 mile wide. In these narrow valleys the soil is flooded frequently and, in some areas adjacent to streambanks, it is stratified with medium-textured silt. In the wider valleys this soil is usually adjacent to Amana or Nodaway soils that parallel the stream channels. Areas are 20 to 80 acres in size. This soil has the profile described as representative for the Colo series.

Included with this soil in mapping are similar soils in which the dark surface layer extends only to a depth of 30 to 36 inches. In some places areas are included that have several inches of very dark grayish-brown silty overwash covering a surface layer of black silty clay loam. A few small areas that are slightly ponded and are wet most of the time are shown on the maps by the wet spot symbol.

Runoff is slow on this soil. Most areas have poor drainage and swales that pond when streams overflow. Tilth is generally good. Under proper moisture conditions this soil is friable and easy to till.

Most areas of this soil are used for crops. Some small areas not accessible to machinery remain in pasture. This soil is well suited to corn and soybeans where wetness is controlled. Capability unit IIw-2; woodland suitability group 5w3.

Colo silty clay loam, 2 to 5 percent slopes (133B).—This soil is in nearly level, slightly concave bottom lands in upland drainageways and narrow valleys. Areas of this soil are generally rather long and narrow in shape and 10 to more than 20 acres in size.

Included with this soil in mapping are small areas of Ely, Radford, and Zook soils.

Runoff is slow on this soil. The hazard of erosion is slight. The surface layer is friable and easy to till. Farming operations are delayed in some places because of wetness.

This soil is in rather narrow areas that are managed along with adjacent soils. It is well suited to corn, soybeans, and hay. Capability unit IIw-3; woodland suitability group 5w3.

Colo-Ely silty clay loams, 2 to 5 percent slopes (11B).—This complex is along small drainageways and creeks on uplands throughout the county. These soils are so intermingled that it is impractical to map each one separately. This complex is in areas as much as a mile or more in length but only 150 to 400 feet in width and 3 to 50 acres in size. The Colo soil is typically along the waterways and makes up about 60 percent of the complex. The Ely soil is in fairly uniform bands along the edges of the unit at the base of slopes and makes up about 40 percent of the complex. In many places areas of this complex are cut by channels or gullies that cannot be crossed by farm machinery.

Included with these soils in mapping are small areas of Judson and Olmitz soils, which generally are slightly upslope from the Ely soils. Some areas have a layer of moderately dark colored silty overwash 7 to 18 inches thick. Small areas of Radford and Zook soils are also included. Small wet spots less than 1 acre in size are shown on the soil by the wet spot symbol.

This complex is seasonally wet because of overflow and a high water table. Most of this complex is farmed along with surrounding soils because the individual areas are generally too small or too narrow to be cultivated separately.

This complex is suited to row crops where it is drained adequately. Capability unit IIw-3; woodland suitability group 5w3.

Downs Series

The Downs series consists of deep, well-drained soils that formed on loess-covered benches in the valleys of the larger streams in the county. Slopes are 2 to 5 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark grayish-brown silt loam 9 inches thick. The subsurface layer is dark grayish-brown silt loam 5 inches thick. The subsoil extends to a depth of 56 inches. The upper part is brown and dark yellowish-brown silty clay loam that has gray silt coatings on ped faces, and the middle is yellowish-brown silty clay loam that has brown coatings and gray silt coatings on ped faces. The lower part of the subsoil is yellowish-brown light silty clay loam that has light brownish-gray mottles. The underlying material is yellowish-brown light silty clay loam that has light olive-gray mottles.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is generally slightly acid unless limed and is moderate in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium.

Downs soils are well suited to row crops and hay.

Representative profile of Downs silt loam, benches, 2 to 5 percent slopes, in a cultivated area on a bench near the North Skunk River, 640 feet west and 410 feet north of the SE. corner of NW1/4SE1/4 sec. 16, T. 77 N., R. 15 W.:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) when crushed and grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—9 to 14 inches, dark grayish-brown (10YR 4/2) heavy silt loam, very dark grayish-brown (10YR 3/2) coatings on ped faces, light brownish gray (10YR 6/2) when dry; weak, medium, platy structure that parts to weak, very fine, subangular blocky; friable; slightly acid; clear, smooth boundary.

B1t—14 to 20 inches, brown (10YR 4/3) light silty clay loam, dark-brown (10YR 3/3) coatings on ped faces; moderate, fine, angular and subangular blocky structure; friable; thin, discontinuous clay films; many gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B21t—20 to 28 inches, dark yellowish-brown (10YR 4/4) silty clay loam, brown (10YR 4/3) coatings on ped faces; moderate, medium and fine, subangular blocky structure; friable; thin, discontinuous clay films; many gray silt coatings on ped faces; medium acid; gradual, smooth boundary.

B22t—28 to 36 inches, yellowish-brown (10YR 5/4) silty clay loam, brown (10YR 4/3) coatings on ped faces; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; friable; thin, discontinuous clay films;

many gray silt coatings on ped faces; common roots; medium acid; gradual, smooth boundary.

B31t—36 to 45 inches, yellowish-brown (10YR 5/4) light silty clay loam; few, fine, distinct mottles of light brownish gray (2.5Y 6/3); brown (10YR 5/3) coatings on ped faces; weak, coarse, prismatic structure that parts to weak, medium, subangular blocky; friable; thin, discontinuous clay films; many gray silt coatings on ped faces; medium acid; smooth, diffused boundary.

B32t—45 to 56 inches, yellowish-brown (10YR 5/4) light silty clay loam; few, fine, distinct mottles of light brownish gray (2.5Y 6/2), brown (10YR 5/3) coatings on ped faces; weak, coarse, prismatic structure; friable; thin, discontinuous clay films; strongly acid; diffused boundary.

C—56 to 72 inches, yellowish-brown (10YR 5/4) light silty clay loam; common, medium, distinct mottles of light olive gray (5Y 6/2); massive; friable; few, very thin, patchy clay films; few roots to a depth of 60 inches; common tubular pores; medium acid.

The A1 horizon is typically silt loam but ranges to light silty clay loam. Thickness ranges from 6 to 10 inches. This horizon is very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1). The maximum content of clay in the subsoil ranges from 30 to 35 percent. The thickness of loess over the alluvium ranges from 6 to 10 feet.

Downs soils are associated with the Ladoga and Fayette soils. They are lower in content of clay than Ladoga soils. Downs soils have a thicker A1 horizon and more depth to the B horizon than Fayette soils.

Downs silt loam, benches, 2 to 5 percent slopes (T162B).—This soil has convex slopes and is on high benches in the valleys of the larger streams. Areas of this soil are irregularly shaped and are 5 to 30 acres in size. This soil has the profile described as representative for the Downs series.

Included with this soil in mapping are small areas where 5 to 18 inches of fine sandy material is in the surface layer. These areas are shown on the map by a sand spot symbol. Also included are areas of a soil similar to this one that has a thicker surface layer. This soil has no subsurface layer and few, if any, gray silt coatings on faces of peds in the subsoil.

Runoff is medium in this soil. Soil blowing is a hazard in winter and early in spring unless the soil is protected. Water erosion is also a hazard. The surface layer is friable and easy to till. Tilth is good.

This soil is well suited to corn, soybeans, and hay if erosion is controlled. Capability unit IIe-1; woodland suitability group 1o1.

Ely Series

The Ely series consists of deep, somewhat poorly drained soils that formed in silty alluvium. The alluvium has been washed from adjacent soils that formed in loess on uplands. Ely soils have slightly concave slopes and are along the edges of valleys on foot slopes and alluvial fans. Slopes are 2 to 5 percent. The native vegetation was grass.

In a representative profile the surface layer is light silty clay loam about 25 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil extends to a depth of about 70 inches and is silty clay loam. It is very dark grayish brown in the upper part; dark grayish brown with dark yellowish-brown mottles in the middle; and mottled, grayish brown, dark yellowish brown, and strong brown in the lower part.

Available water capacity is high in these soils. Permeability is moderate, but in some places these soils receive some seepage water. The surface layer is generally neutral and is high in content of organic matter. The subsoil is very low in available phosphorus and potassium.

These soils are subject to flooding, and as a result silty sediment is deposited on the surface. The hazard of erosion is slight during hard rains, but erosion is not so great a hazard to young plants as is the accumulation of silty material on the surface.

Ely soils can be cultivated intensively to row crops, but individual areas generally are so small that they are managed along with areas of adjacent soils and in some places are used for hay or pasture.

Representative profile of Ely silty clay loam, 2 to 5 percent slopes, in a pasture 100 feet north and 850 feet east of the SW. corner of sec. 35, T. 76 N., R. 16 W.:

A1—0 to 16 inches, black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) when dry; moderate, medium, granular structure; friable; neutral; gradual, smooth boundary.

A3—16 to 25 inches, very dark gray (10YR 3/1) light silty clay loam, very dark grayish brown (10YR 3/2) when crushed and dark gray (10YR 4/1) when dry; moderate, medium, granular structure; friable; common roots; few gray silt coatings on ped faces; slightly acid; gradual, smooth boundary.

B1—25 to 31 inches, very dark grayish-brown (10YR 3/2) silty clay loam; weak, medium, subangular blocky structure; very dark gray (10YR 3/1) coatings on ped faces; friable; slightly acid; gradual, smooth boundary.

B21—31 to 38 inches, very dark grayish-brown (10YR 3/2) silty clay loam; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; friable; common, fine, faint mottles of dark brown (10YR 3/3); slightly acid; gradual, smooth boundary.

B22—38 to 48 inches, dark grayish-brown (10YR 4/2) light silty clay loam; weak, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; common, fine, faint mottles of dark yellowish-brown (10YR 4/4); neutral; gradual, smooth boundary.

B23—48 to 58 inches, dark grayish-brown (2.5Y 4/2) light silty clay loam; weak, medium, subangular blocky structure; friable; common, fine, faint mottles of brown (10YR 5/3) and grayish brown (2.5Y 5/2); thin, discontinuous clay films on vertical ped faces; neutral; gradual, smooth boundary.

B3–58 to 70 inches, mottled grayish-brown (2.5Y 5/2), dark yellowish-brown (10YR 4/4), and strong-brown (7.5YR 5/6 and 5/8) silty clay loam; weak, medium and coarse, subangular blocky structure; friable; few, thin, dark-gray (10YR 4/1) clay flows; neutral.

The A horizon ranges from 22 to 28 inches in thickness. It is black (10YR 2/1) or very dark brown (10YR 2/2). In places in cultivated areas the Ap horizon ranges to very dark grayish brown (10YR 3/2), and in places the A3 horizon has a few gray silt coatings on faces of peds. The B1 horizon ranges from very dark grayish brown (10YR 3/2) to dark brown (10YR 4/2). It is light or medium silty clay loam. In places the lower part of the B2 horizon and the B3 horizon have thin clay films and clay flows below a depth of 40 inches. The A and B horizons range from neutral to slightly acid. Depth to the C horizon ranges from 50 to 66 inches.

Ely soils are associated with Judson and Olmitz soils. They have more mottles and are grayer in the B horizon than Judson soils and have less sand in the A and B horizons than Olmitz soils.

Ely silty clay loam, 2 to 5 percent slopes (428B).—This soil is on slightly concave or nearly linear foot slopes and alluvial fans along the edges of valleys. Areas of this soil generally are rather long and narrow and are somewhat parallel to the stream. They are generally 5 to 20 acres in size. This soil has the profile described as representative for the Ely series.

Included with this soil in mapping are areas of Ely silty clay loam, 5 to 9 percent slopes. Also included are small areas of Colo, Radford, and Judson soils.

Runoff is medium on this soil. In some places wetness may delay farming operations in spring because of seepage

or runoff from soils at higher elevations. The surface layer is friable and easy to till where moisture conditions are favorable. Tilth is good. The hazard of erosion is slight. Siltation is a hazard in places.

This soil is well suited to corn, soybeans, and hay where wetness and other hazards are controlled. Capability unit IIe-2; woodland suitability group 3w1.

Fayette Series

The Fayette series consists of deep, well-drained soils that formed in loess. These soils are along the edges of valleys of the Des Moines and Skunk Rivers. Slopes are 2 to 18 percent. The native vegetation was trees.

In a representative profile the surface layer is very dark gray silt loam 4 inches thick. The subsurface layer is dark grayish-brown or brown silt loam 5 inches thick. The subsoil extends to a depth of 47 inches and is light silty clay loam. It is yellowish brown with gray silt coatings on ped faces in the upper and middle parts and yellowish brown with light brownish-gray mottles and soft black oxides in the lower part. The underlying material is yellowish-brown silt loam that has mottles of light brownish gray and soft black oxides.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is medium or strongly acid unless it has been limed and is low or very low in content of organic matter. The subsoil is high in available phosphorus and very low in available potassium.

Fayette soils are subject to erosion. Under proper management they are well suited to row crops where slopes are gentle or moderate. Fayette soils are well suited to pasture or trees where slopes are strong or steep.

Representative profile of Fayette silt loam, 14 to 18 percent slopes, moderately eroded, in a pasture 960 feet west and 1,320 feet north of the SE. corner of sec. 5, T. 77 N., R. 15 W.:

A1—0 to 4 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 6/1) when dry; weak, fine, platy structure; friable; medium acid; clear, smooth boundary.

A21—4 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, light gray (10YR 7/2) when dry; moderate, fine, platy structure; friable; slightly acid; clear, smooth boundary.

A22—7 to 9 inches, brown (10YR 5/3) silt loam, very pale brown (10YR 7/3) when dry; weak, coarse, platy structure that parts to weak, very fine, subangular blocky; friable; many gray silt coatings on ped faces; slightly acid; gradual, smooth boundary.

B1—9 to 13 inches, yellowish-brown (10YR 5/4) light silty clay loam, very pale brown (10YR 7/3) when dry; moderate, fine, blocky structure that parts to strong, fine, subangular blocky; friable; thin gray silt coatings on ped faces; strongly acid; gradual, smooth boundary.

B21t—13 to 23 inches, yellowish-brown (10YR 5/4) light silty clay loam; strong, fine, blocky and subangular blocky structure; friable; moderately thick, discontinuous coatings of dark yellowish brown (10YR 4/4) and discontinuous gray silt coatings on ped faces; common roots to a depth of 16 inches; strongly acid; gradual, smooth boundary.

B22t—23 to 35 inches, yellowish-brown (10YR 5/4) silty clay loam; moderate, medium and fine, blocky and subangular blocky structure; friable; thick, discontinuous clay films; strongly acid; gradual, smooth boundary.

B3—35 to 47 inches, yellowish-brown (10YR 5/4) light silty clay loam; common, medium, distinct mottles of light brownish gray (10YR 6/2); weak, medium, subangular blocky structure; friable; few, soft, fine black oxides; common tubular pores; few fine roots; strongly acid; gradual boundary.

C—47 to 60 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, distinct mottles of light brownish-gray (2.5Y 6/2); massive with some vertical cleavage; friable; few soft black oxides; strongly acid.

The A1 horizon ranges from 1 to 4 inches in thickness. It is typically very dark gray (10YR 3/1) but ranges to very dark brown (10YR 2/2) or very dark grayish brown. The Ap horizon is generally dark grayish brown (10YR 4/2). The A2 horizon ranges from 4 to 10 inches in thickness. In the B2t hroizon the maximum content of clay is 30 to 35 percent. Grayish mottles are in the B horizon below a depth of 30 inches in places.

Fayette soils are associated with Clinton, Downs, and Seaton soils. They have less clay in the B2 horizon than Clinton soils and a thinner A1 horizon than Downs soils. Fayette soils have more clay in the B horizon than Seaton soils.

Fayette silt loam, 2 to 5 percent slopes (163B).—This soil is on convex ridges and side slopes on uplands and is present in places along the higher parts of dissected landscapes. Areas of this soil are generally long and narrow, have irregular boundaries, and are generally 5 to 20 acres in size.

This soil has a profile similar to that described as representative for the Fayette series, but the surface and subsurface layers are thicker.

Included with this soil in mapping are small areas of Clinton and Downs soils.

Runoff is medium on this soil. The hazard of water erosion is moderate. The surface layer is low in content of organic matter, is friable, and is easy to till. Tilth is good.

This soil is well suited to corn, soybeans, and hay. Capability unit IIe-1; woodland suitability group 1o1.

Fayette silt loam, 5 to 9 percent slopes, moderately eroded (163C2).—This soil is on narrow, convex ridges and side slopes on uplands. Areas of this soil are generally long and narrow, have somewhat irregular boundaries, and are generally 10 to 30 acres in size.

This soil has a profile similar to that described as representative for the Fayette series, but the surface and subsurface layers are thicker.

Included with this soil in mapping are small areas of Clinton and Seaton soils.

Runoff is medium on this soil. The hazard of erosion is moderate. The surface layer is low in content of organic matter and is friable. Tilth is good.

This soil is well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Fayette silt loam, 9 to 14 percent slopes, moderately eroded (163D2).—This soil is on narrow, convex ridges and side slopes on uplands. It is generally along the rounded edges of divides in dissected landscapes above the loess-till contact line or above the loess-sandstone contact line. Areas of this soil are generally long and narrow, have quite irregular boundaries, and are generally 10 to 30 acres in size.

Included with this soil in mapping are small areas of severely eroded Fayette soil and small sandy areas that are shown on the map by special symbol. Also included are small areas of Clinton and Seaton soils.

Runoff is rapid on this soil. The hazard of erosion is moderate or severe. The surface layer is low in content of organic matter and is friable. Tilth is good.

This soil is moderately suited to corn and soybeans. It is well suited to pasture or trees. Capability unit IIIe-2; woodland suitability group 1o1.

Fayette silt loam, 14 to 18 percent slopes, moderately eroded (163E2).—This soil is on convex side slopes of strongly dissected uplands. It is generally above the loess-till or loess-sandstone contact line but extends down to the valley floor in some places. Areas of this soil are quite long and narrow, have irregular boundaries, and are generally 10 to 30 acres in size. This soil has the profile described as representative for the Fayette series.

Included with this soil in mapping are small areas of severely eroded soils and small sandy areas that are shown on the map by special symbol. Also included are small areas of Clinton and Seaton soils.

Runoff is rapid on this soil. The hazard of erosion is severe. The surface layer is low in content of organic matter and is friable. Tilth is good.

This soil is poorly suited to corn and soybeans. It is well suited to hay, pasture, trees, or wildlife. Capability unit IVe-1; woodland suitability group 1o1.

Flagler Series

The Flagler series consists of somewhat excessively drained soils that formed in sandy alluvium. These soils are nearly level on the bottom lands or low benches of the larger streams. Slopes are less than 2 percent. The native vegetation was grass.

In a representative profile the surface layer is 22 inches thick. It is black fine sandy loam in the upper part and very dark grayish-brown sandy loam in the lower part. The subsoil, between depths of 22 and 33 inches, is brown sandy loam that has a few small pebbles. The underlying material is dark yellowish-brown loamy sand to a depth of 65 inches.

Available water capacity is low in these soils. Permeability is moderately rapid to rapid. The surface layer is moderate in content of organic matter. The subsoil is very low in available phosphorus and potassium.

Flagler soils are flooded at times in spring where they are not protected. These soils are moderately well suited to row crops. They are also suited to hay or pasture.

Representative profile of Flagler fine sandy loam, 0 to 2 percent slopes, in a meadow 155 feet east and 600 feet north of the SW. corner of NW¼SW¼ sec. 31, T. 74 N., R. 15 W.:

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam; weak, very fine, granular structure; very friable; neutral; clear, smooth boundary.

A12—8 to 17 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; very dark brown (10YR 2/2) coatings on ped faces; weak, medium, subangular blocky structure that parts to weak, fine and very fine, granular; very friable; neutral; gradual, smooth boundary.

A3—17 to 22 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, moderate, subangular blocky structure that parts to weak, very fine, granular; friable; slightly acid; gradual, smooth boundary.

B2—22 to 33 inches, brown (7.5YR 4/2) sandy loam; weak, coarse, subangular blocky structure that parts to moderate, fine, granular; friable; few small pebbles; medium acid; abrupt, smooth boundary.

IIC—33 to 65 inches, dark yellowish-brown (10YR 4/4) loamy sand (estimated 12 percent gravel by volume); single grained; loose; stratified in lower part with thin strata (2 to 20 millimeters in thickness) of brown (7.5YR 4/2) fine sand; slightly acid.

The A horizon ranges from 15 to 24 inches in thickness. The A1 horizon is typically fine sandy loam but ranges to loamy sand and is black (10YR 2/1) or very dark brown (10YR 2/2). The B horizon is typically very dark grayish brown (10YR 3/2) but ranges from very dark brown (10YR 2/2) to dark brown (10YR 3/3). It is generally sandy loam but ranges to loamy sand. Content of clay ranges from 7 to 15 percent. Depth to the C horizon ranges from 30 to 40 inches. Texture of the C horizon ranges from loamy sand to gravelly sand.

Flagler soils are associated with Landes and Sparta soils. They are more strongly developed than Landes soils, and unlike the Landes soils, the Flagler soils have a B horizon. Also, Flagler soils lack the stratification of Landes soils. They contain less sand and more clay than Sparta soils.

Flagler fine sandy loam, 0 to 2 percent slopes (284).—This soil is on smooth or gently undulating flood plains along the larger streams. It is in irregularly shaped areas that are generally 10 to 40 acres in size. This soil has the profile described as representative for the Flagler series.

Included with this soil in mapping are small areas of Landes soils.

Runoff is slow on this soil. Water enters this soil rapidly, but the soil tends to be droughty. Soil blowing is a hazard in winter and early in spring unless the surface is protected. The surface layer is very friable and easy to till.

This soil is moderately suited to corn and soybeans. It is well suited to hay, meadow, or pasture. Capability unit IIIs-1; woodland suitability group 4s1.

Gara Series

The Gara series consists of deep, well drained or moderately well drained soils that formed in glacial till. These soils are at lower elevations on sloping uplands. Slopes are convex and range from 9 to 25 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark gray loam 7 inches thick. The subsurface layer is 5 inches thick and is dark grayish-brown and very dark gray loam. The subsoil, about 32 inches thick, is brown and very dark gray light clay loam in the upper part, brown and dark yellowish-brown clay loam in the middle, and yellowish-brown light clay loam with slightly brighter yellowish-brown and light brownish-gray mottles in the lower part. The underlying material, at a depth of 44 inches, is mottled, yellowish-brown and light brownish-gray light clay loam.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is slightly acid unless it has been limed and is low in content of organic matter. The subsoil is very low to low in available phosphorus and very low in available potassium.

The less sloping Gara soils are used for crops and hay. The more strongly sloping soils are suited to pasture or trees.

Representative profile of Gara loam, 9 to 14 percent slopes, moderately eroded, in a pasture 500 feet east and 150 feet north of the SW. corner of sec. 28, T. 76 N., R. 17 W.:

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, very dark grayish brown (10YR 3/2) when crushed, dark grayish brown (10YR 4/2) when dry; weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—7 to 12 inches, dark grayish-brown (10YR 4/2) loam, mixing of very dark gray (10YR 3/1) in places; dark grayish brown (10YR 4/2) when crushed, grayish brown (10YR 5/2) when dry; weak, fine, subangular blocky structure that parts to weak, fine, granular; friable; slightly acid; clear, smooth boundary.

B1—12 to 18 inches, brown (10YR 4/3) clay loam and some very dark gray (10YR 3/1) light clay loam; moderate, fine and medium, subangular blocky structure; friable; thin, grayish-brown silt coatings on ped faces; medium acid; clear, smooth boundary.

B21t—18 to 25 inches, dark yellowish-brown (10YR 4/4) clay loam that has yellowish-brown (10YR 4/4) coatings on ped faces; moderate, medium and coarse, subangular blocky structure; firm; thin, grayish-brown silt coatings on ped faces; thin, discontinous clay films; medium acid; gradual, smooth boundary.

B22t—25 to 38 inches, dark yellowish-brown (10YR 4/4) clay loam; weak, medium, prismatic structure that parts to moderate, fine and medium, subangular blocky; firm; thin, discontinuous clay films; medium acid; gradual, smooth boundary.

B3t—38 to 44 inches, yellowish-brown (10YR 5/4) light clay loam; few, fine, distinct mottles of light brownish gray (10YR 6/2) and faint mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to moderate, fine and medium, subangular blocky; firm; thin, discontinuous clay films; medium acid; gradual, smooth boundary.

C—44 to 60 inches, mottled, yellowish-brown (10YR 5/4, 5/6) and light brownish-gray (10YR 6/2) light clay loam; structureless (massive), some vertical cleavage; firm; slightly acid.

The A1 or Ap horizon is loam or silt loam that ranges from 6 to 10 inches in thickness where it is not eroded. It is very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). Where this soil is undisturbed, an A2 horizon that is loam or silt loam and 3 to 6 inches thick is present. In the B1 horizon and the upper part of the B2 horizon, peds have thin, gray to grayish-brown, grainy silt coatings. Content of clay in the B2t horizon is generally 32 to 35 percent but in places is 35 to 38 percent. Depth to the C horizon ranges from 36 to 70 inches. This horizon is light to heavy clay loam.

Gara soils are associated with Armstrong and Lindley soils and formed in material similar to that formed in by the Lindley and Shelby soils. They have a thicker surface layer, a greater depth to the B horizon, and less distinct silt coatings on peds in the B horizon than Lindley soils. Gara soils have a thinner surface layer and are more acid than Shelby soils. They are neither so high in content of clay nor so reddish in the B horizon as Armstrong soils.

Gara loam, 9 to 14 percent slopes, moderately eroded (179D2).—This soil is generally on convex side slopes and nose slopes of upland divides. It is generally on the lower parts of the slopes and extends down to the edge of valleys or drainageways. The areas are rather long and narrow and have irregular boundaries. They are 10 to 60 acres or more in size and extend horizontally for distances of up to one-half mile or more. This soil has the profile described as representative for the Gara series.

Included with this soil in mapping in places are areas of Shelby loam, and along the upper boundary of this unit, some small, narrow areas of Armstrong soil. Included in places along the lower boundary are areas of a similar soil that is underlain, at a depth below 40 inches, by material weathered from sandstone or shale or by a clayey layer. Also included are very small areas of severely eroded soils that have reddish clay at or near the surface and outcrops of shale or sandstone. These are shown on the map by special symbols.

Runoff is medium or rapid on this soil. The hazard of erosion is moderate to severe. The surface layer is friable. Tilth is generally moderate. It is variable, however, depending upon the extent of erosion and the amount of subsoil material that has mixed into the plow layer.

This soil is moderately suited to corn and soybeans. It is well suited to hay, pasture, or trees. Many areas of this soil are good locations for ponds. Capability unit IVe-3; woodland suitability group 2o1.

Gara loam, 14 to 18 percent slopes, moderately eroded (179E2).—This soil is on dissected side slopes and convex nose slopes on uplands. It is in lower areas and generally extends down to valleys or drainageways. The areas are long and narrow and have irregular boundaries. They range from 10 to more than 80 acres in size and extend horizontally for distances of up to one-half mile or more.

This soil has a profile similar to that described as representative for the Gara series, but the surface layer is typically a little thinner and depth to the subsoil is slightly less.

Included with this soil in mapping are small areas of Caleb soil and, in places along the upper boundary, long, narrow areas of Armstrong soil. Areas of severely eroded soils that have reddish clay at or near the surface and outcrops of sandstone, limestone, or shale are also included and are shown on the map by special symbols.

Runoff is rapid on this soil. The hazard of water erosion is severe.

This soil is poorly suited to crops. It is well suited to hay, pasture, or trees. Many areas are good locations for ponds. Capability unit VIe-1; woodland suitability group 2o1.

Gara loam, 18 to 25 percent slopes, moderately eroded (179F2).—This soil is on the lower parts of dissected side slopes and convex nose slopes on uplands. It generally extends down to valleys or drainageways. The areas are long and narrow and have irregular boundaries. They range from 10 to more than 40 acres in size and extend horizontally for distances up to one-fourth mile or more.

This soil has a profile similar to that described as representative for the Gara series, but the surface layer is thinner and depth to the subsoil is less.

Included with this soil in mapping are areas of Caleb and Lindley soils. Areas of severely eroded Gara soil and small outcrops of sandstone, limestone, or shale are also included and are shown on the map by special symbols.

Runoff is rapid on this soil. The hazard of water erosion is severe.

This soil is not suited to crops. It is suited to pasture, trees, or wildlife habitat, and it provides suitable locations for ponds. Capability unit VIIe-1; woodland suitability group 3r1.

Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded (993D2).—This complex is on convex hillsides below the loess-till contact line. Areas are rather long and narrow and extend horizontally around hillsides and into drainageways. These areas are generally 10 to 30 acres in size. The Gara soil, which is downslope from the Armstrong soil, makes up about 70 to 85 percent of the complex. The Armstrong soil, which is higher in content of clay than the Gara soil and at higher elevation, makes up 15 to 30 percent of the complex.

These soils have profiles similar to those described as representative for their respective series, but the surface layer of these soils is thinner.

Included with these soils in mapping are uneroded Armstrong and Gara soils. Also included, along the upper boundary of the areas, are small areas of Clarinda soils. Small areas of a soil that is underlain by shale are also included in places along the lower boundary.

Runoff is moderate or rapid on soils of this complex. The hazard of erosion is moderate. A seep line develops in places in the more permeable soil above the Armstrong soil and also develops in the Armstrong soil during wet seasons.

This complex is rather poorly suited to corn and soybeans. It is well suited to hay or pasture. Capability unit IVe-4; woodland suitability group 2o1.

Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded (993E2).—This complex is on convex hillsides on uplands below the loess-till contact line. Areas are long and narrow and extend horizontally around hillsides and into drainageways. These areas are generally 15 to 40 acres in size. The Gara soil is downslope from the Armstrong soil and makes up about 75 to 85 percent of the complex. The Armstrong soil, which is higher in content of clay, is in the upper parts of the mapped area and makes up about 15 to 25 percent of the complex.

These soils have profiles similar to those described as representative for their respective series, but the surface layer of these soils is thinner.

Included with these soils in mapping are areas of uneroded Gara and Armstrong soils. Also included are small areas where the soil is severely eroded. These are shown on the map by a special symbol. A soil that is underlain by shale is also included along the lower boundary of this complex in some places.

Runoff is high on soils of this complex. The hazard of erosion is severe. A seep line develops in places in the more permeable soil just above the Armstrong soil during wet seasons. In many places the surface layer of the eroded Armstrong soil is sticky when wet and hard when dry.

This complex is poorly suited to corn and soybeans. It is well suited to hay, pasture, or trees. Capability unit VIe-1; woodland suitability group 2o1.

Givin Series

The Givin series consists of deep, somewhat poorly drained soils that formed in loess. These soils are on broad upland ridges and on high stream benches. Slopes are 1 to 3 percent. The native vegetation was a mixture of grass and trees.

In a representative profile the surface layer is very dark grayish-brown silt loam about 8 inches thick. The subsurface layer extends to a depth of about 12 inches. It is dark grayish-brown silt loam that is distinctly lighter in color when dry. The subsoil extends to a depth of about 69 inches and is silty clay loam. It is dark grayish brown in the upper part and has yellowish-brown and grayish-brown mottles below a depth of 20 inches in this part. The middle is mottled and is grayish brown and yellowish brown. The lower part of the subsoil is light brownish gray. It has strong-brown and yellowish-brown mottles. Faces of peds in the subsoil have silt coatings and clay films. The underlying material is mottled, light brownish-gray and strong-brown silt loam.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is moderate in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium. Soil blowing is a hazard in winter where the surface is not protected.

These soils are acid unless limed and require applications of lime for intensive crop growth. Givin soils are well suited to row crops and hay. Most areas are used for these purposes.

Representative profile of Givin silt loam, 1 to 3 percent slopes, in a cultivated area about 30 feet west and 300 feet north of the SE. corner of the NE¼NW¼ sec. 17, T. 75 N., R. 17 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, medium and fine, granular structure; friable; neutral; abrupt, smooth boundary.

A2—8 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; moderate, fine, platy structure; friable; neutral; clear, smooth boundary.

B1—12 to 17 inches, brown (10YR 4/3) light silty clay loam; moderate, fine, subangular blocky structure that parts to moderate fine, angular blocky; few dark grayish-brown (10YR 4/2) coatings on ped faces; common light brownish-gray (10YR 6/2) silt coating on ped faces; strongly acid; clear, smooth boundary.

B21t—17 to 22 inches, dark grayish-brown (10YR 4/2) silty clay loam; few fine mottles of yellowish brown (10YR 4/2); moderate, fine, angular blocky structure; friable; thin, continuous clay films; few very dark gray (10YR 3/1) coatings on ped faces; common light brownish-gray (10YR 6/2) silt coatings on ped faces; strongly acid; clear, smooth boundary.

B22t—22 to 32 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam; dark brown (10YR 3/3) and dark grayish-brown (10YR 4/2) coatings on ped faces; common, fine grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/4) mottles; moderate, medium and fine, angular blocky structure; firm; thick, continuous clay films; strongly acid; gradual, smooth boundary.

B23t—32 to 39 inches, mottled, grayish-brown (2.5YR 5/2) and yellowish-brown (10YR 5/6) heavy silty clay loam; moderate, medium, prismatic structure that parts to moderate, medium and fine, angular blocky; firm; thick, continuous clay films on vertical ped faces; clay coatings or flows along few old root channels; medium acid; gradual, smooth boundary.

B31—39 to 47 inches, light brownish-gray (2.5YR 6/2) heavy silty clay loam; many, fine, distinct mottles of strong brown (7.5Y 5/6) and yellowish brown (10YR 5/6); moderate, medium, prismatic structure; thin, continuous clay films on vertical ped faces; few clay flows along root channels; very dark brown (10YR 2/2) and grayish-brown (2.5Y 5/2) coatings on ped faces; medium acid; gradual, smooth boundary.

B32—47 to 69 inches, light brownish-gray (2.5Y 6/2) light silty clay loam; many, medium, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); weak, coarse, prismatic structure; common clay flows and clay balls of very dark brown (10YR 2/2); medium acid; gradual, smooth boundary.

C—69 to 93 inches, mottled, light brownish-gray (2.5Y 6/2) and strong-brown (7.5YR 5/6) heavy silt loam; massive; friable; common oxides; slightly acid.

The A1 horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and ranges in thickness from 6 to 10 inches. In places it has grainy silt coatings on ped faces. The A horizon ranges from neutral to medium acid depending upon lime applications. Depth to the B horizon ranges from 9 to 15 inches. The B1 horizon is light to medium silty clay loam. Structure is subangular blocky or angular blocky. The B2t horizon is medium to heavy silty clay loam. Clay films on ped faces range from thin and discontinuous to thick and continuous. The B3 and C horizons have predominant hues of 2.5Y to 5Y. Depth to the C horizon ranges from 60 to 72 inches.

Gavin soils are associated with Ladoga and Mahaska soils, which formed in similar material. They have a thinner dark A1 horizon than Mahaska soils and a light-colored A2 horizon, which is lacking in Mahaska soils. Givin soils have a grayer B2t horizon than Ladoga soils and, unlike Ladoga soils, have mottles in the upper part of the B horizon.

Givin silt loam, 1 to 3 percent slopes (75).—This soil is on uplands and high stream benches. Areas of this soil are generally irregular in shape and 10 to 40 acres in size. This soil has the profile described as representative for the Givin series.

Included with this soil in mapping are small areas of Rubio and Mahaska soils. Also included are small areas of a soil that has a thinner and lighter colored surface layer than this Givin soil. These included areas make up less than 20 percent of the mapping unit.

Runoff is slow on this soil. Tile drainage is needed in places for timely farming operations. The maintenance of good tilth can be a problem.

This soil is used intensively for row crops and is well suited to such use. Capability unit I-1; woodland suitability unit 3w1.

Givin silt loam, benches, 1 to 3 percent slopes (T75).—This soil is on loess-covered benches in the valleys of major streams. Areas of this soil are somewhat irregularly shaped and are 5 to 20 acres in size.

This soil has a profile similar to that described as representative for the Givin series, but alluvium is at a depth of 7 to 15 feet.

Included with this soil in mapping are small areas of Mahaska and Rubio and Taintor silty clay loams. These make up to 20 percent of the mapping unit.

Runoff is slow on this soil. The soil is not subject to

flooding by stream overflow, but in some places it receives runoff from soils upslope.

This soil is used intensively for row crops and is well suited to that use. Capability unit I-1; woodland suitability group 3w1.

Gosport Series

The Gosport series consists of moderately deep, light-colored, moderately well drained soils that formed in shale. These soils have convex slopes and are on uplands. Slopes are 9 to 25 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark grayish-brown silt loam 6 inches thick. The subsurface layer is very thin grayish-brown silt loam that has thin fragments of ironstone. The subsoil extends to a depth of 30 inches and contains thin fragments of limestone. The upper part is grayish-brown silty clay loam that has mottles of reddish brown, and the middle is light brownish-gray and grayish-brown silty clay that has mottles of light olive brown and reddish brown. The lower part of the subsoil is light brownish-gray silty clay that has layers of yellowish-brown hard sandstone 1 inch thick at depths of 24 and 29 inches. The underlying material is weathered gray shale. It has mottles of brownish yellow and contains small fragments of ironstone.

Available water capacity is moderate or high in these soils. Permeability is very slow. The surface layer is generally medium acid unless it has been limed and is moderate to low in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium.

The depth to shale and steepness of slopes make these soils unsuitable for crops. They are used for pasture or trees.

Representative profile of Gosport silt loam, 14 to 18 percent slopes, in a pasture 700 feet north and 700 feet west of the SE. corner of NE¼ sec. 27, T. 74 N., R. 17 W.:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, grayish brown (10YR 5/2) when dry; moderate, fine and medium, granular structure; friable; common roots; medium acid; clear, smooth boundary.

A2—6 to 8 inches, grayish-brown (10YR 5/2) heavy silt loam; brown (10YR 5/3) coatings on ped faces; few, fine, prominent mottles of reddish brown (5YR 4/4); moderate, medium, granular structure; friable; common roots; few thin ironstone fragments; very strongly acid; clear, smooth boundary.

B1—8 to 11 inches, grayish-brown (10YR 5/2) silty clay loam; brown (10YR 5/3) coatings on ped faces; moderate, fine, subangular blocky structure; firm; few roots; few very dark gray (10YR 3/1) clay flows in root channels; few thin ironstone fragments; extremely acid; gradual, smooth boundary.

B21—11 to 19 inches, dark grayish-brown (2.5Y 4/2) and light olive-brown (2.5Y 5/3) silty clay; common, fine, distinct mottles of reddish brown (5YR 4/4); moderate, medium, subangular blocky structure that parts to moderate, fine, subangular blocky; firm; few roots; common very dark gray (10YR 3/1) clay flows in root channels; few thin ironstone fragments; extremely acid; clear, smooth boundary.

B22—19 to 24 inches, mixed grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) silty clay; grayish-brown (2.5Y 5/2) coatings on ped faces; common, fine, prominent mottles of reddish brown (10YR 5/6); moderate, medium, subangular blocky structure that parts to moderate, fine, subangular blocky; firm; few roots; very strongly acid; abrupt, wavy boundary.

B3—24 to 30 inches, light brownish-gray (2.5Y 6/2) silty clay; grayish-brown (10YR 5/2) coatings on ped faces; common, fine, prominent mottles of dark yellowish brown (10YR 4/4) and faint mottles of light olive brown (2.5Y 5/4); weak, medium, subangular blocky structure; firm; very thin dark grayish-brown (10YR 4/2) stains on vertical ped faces; few roots; hard yellowish-brown (10YR 5/6) sandstone layer at depths of 24 to 25 inches and 29 to 30 inches; very strongly acid; abrupt, wavy boundary.

C—30 to 60 inches, light-gray (N 6/0) silty clay shale; many, coarse, distinct mottles of brownish yellow (10YR 6/6); weak, medium and fine, platy structure; friable; common shale and ironstone fragments; common horizontal bedding of very dark gray (N 3/0) on shale fragments; strongly acid.

The A horizon is silt loam to silty clay loam or loam that ranges from 3 to 8 inches in thickness. It is typically very dark grayish brown (10YR 3/2) but ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2). The A2 horizon ranges in thickness from 2 to 4 inches. It is grayish brown (10YR 5/2) or dark grayish brown (10YR 4/2). The B2 horizon is silty clay or clay that has thin layers or fragments of sandstone or lignite. Content of clay ranges from 36 to 58 percent. Depth to the C horizon ranges from 20 to 30 inches.

Gosport soils are associated with Sogn and Boone soils. These soils formed in weathered shale, unlike all other soils in the county. They are deeper and finer textured than the Boone soils, which formed in material weathered from sandstone. Unlike Sogn soils, which are underlain by limestone, Gosport soils are underlain by shale.

Gosport silt loam, 9 to 14 percent slopes (313D).—This soil has convex slopes and is on uplands. It is generally below soils that formed in loess or glacial till. Areas of this soil are generally long and narrow, have irregular boundaries, and are often 30 to more than 80 acres in size.

This soil has a profile similar to that described as representative for the Gosport series, but the subsoil is slightly thicker in this soil, and the shale is slightly deeper.

Included with this soil in mapping are small areas of a similar soil that is less than 20 inches deep over shale, areas of severely eroded Gosport soil, and very small areas where brownish-colored sandstone or ironstone is at the surface.

Runoff is rapid on this soil. The hazard of erosion is severe unless the soil is properly managed.

This soil is not suited to cultivation. It is suited to pasture or trees. Capability unit VIIe-2; woodland suitability group 5w1.

Gosport silt loam, 14 to 18 percent slopes (313E).—This soil has moderately steep, convex slopes and is on uplands. It generally is below soils that formed in loess or glacial till. Areas of this soil are generally long and narrow, have irregular boundaries, and are often 30 to more than 80 acres in size. This soil has the profile described as representative for the Gosport series.

Included with this soil in mapping are areas of shale outcrop less than one-fourth of an acre in size. Also included are very small areas where brownish sandstone or ironstone crop out on the surface. Also included are some areas of severely eroded Gosport soil that are shown on the soil map by a special symbol.

Runoff is rapid on this soil. The hazard of erosion is severe.

This soil is not suited to cultivation. It is suited to pasture or trees. Capability unit VIIe-2; woodland suitability group 5w1.

Gosport silt loam, 18 to 25 percent slopes (313F).—This soil has convex slopes and is on uplands. It generally is on the lower part of slopes just above valley floors or foot slopes. Areas of this soil are generally long and narrow, have irregular boundaries, and are 20 to more than 50 acres in size.

This soil has a profile similar to that described as representative for the Gosport series, but the surface layer and subsoil are thinner and this soil is shallower to shale.

Included with this soil in mapping are areas of shale outcrop less than 1 acre in size. Also included are very small

areas where brownish-colored sandstone or ironstone crop out on the surface. Also included are a few severely eroded areas 1 to 10 acres in size.

Runoff is rapid on this soil. The hazard of erosion is severe.

This soil is not suitable for cultivation. It is suited to pasture, trees, or wildlife. Capability unit VIIe-2; woodland suitability group 5w1.

Grundy Series

The Grundy series consists of deep, somewhat poorly drained soils that formed in loess. These soils are on gently sloping or moderately sloping uplands. Slopes are 2 to 9 percent. The native vegetation was grass.

In a representative profile the surface layer is black light silty clay loam 11 inches thick. The subsoil extends to a depth of 52 inches. It is very dark gray silty clay loam in the upper part, very dark gray or dark grayish-brown and grayish-brown light silty clay that has mottles of yellowish brown and brownish-yellow silty clay loam in the middle, and light-gray silty clay loam in the lower part. The underlying material is light-gray light silty clay loam. Soft very dark brown oxides are in the lower part of the subsoil and in the underlying material.

Available water capacity is high in these soils. Permeability is slow. The surface layer is medium acid unless it has been limed, and it is moderate or high in content of organic matter. The subsoil is low to very low in available phosphorus and medium to low in available potassium. In wet seasons Grundy soils need drainage to make timely farming operations possible.

Grundy soils are moderately well suited to and are mainly used for row crops and hay where drainage is adequate.

Representative profile of Grundy silty clay loam, 2 to 5 percent slopes, in a pasture 950 feet west and 1,300 feet north of the SE. corner of sec. 31, T. 74 N., R. 17 W.:

A1—0 to 11 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when crushed; moderate, fine and medium, granular structure; friable; common roots; medium acid; clear, smooth boundary.

B1—11 to 15 inches, very dark gray (10YR 3/1) silty clay loam, very dark grayish brown (10YR 3/2) when crushed; moderate, fine, subangular blocky structure; friable; common roots; medium acid; clear, smooth boundary.

B21t—15 to 19 inches, very dark gray (10YR 3/1) silty clay loam, very dark grayish brown (10YR 3/2) when crushed; strong, fine, subangular blocky structure; friable; moderately thick, discontinuous clay films; few roots; medium acid; clear, smooth boundary.

B22t—19 to 23 inches, very dark gray (10YR 3/1) and dark grayish-brown (10YR 4/2) light silty clay; few, fine, distinct mottles of yellowish brown (10YR 5/4); strong, fine, subangular blocky structure; firm; moderately thick, discontinuous clay films; medium acid; clear, smooth boundary.

B23t—23 to 31 inches, dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) light silty clay; many, fine, distinct mottles of yellowish brown (10YR 5/6); moderate, fine and medium, subangular blocky structure; firm; moderately thick, discontinuous clay films; medium acid; gradual, smooth boundary.

B31t—31 to 43 inches, mottled, light-gray (2.5Y 7/2), light yellowish-brown (10YR 6/4), and brownish-yellow (10YR 6/6) heavy silty clay loam; moderate, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; thin, discontinuous clay films; few dark grayish-brown (10YR 4/2) clay balls; common very dark brown (10YR 2/2) oxides; medium acid; gradual, smooth boundary.

B32t—43 to 52 inches, mottled, light-gray (2.5Y 7/2), light yellowish-brown (10YR 6/4), and brownish-yellow (10YR 5/6) silty clay loam; weak, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; few very dark brown (10YR 2/2) oxides; slightly acid; gradual, smooth boundary.

C—52 to 96 inches, light-gray (2.5Y 7/2) light silty clay loam; massive; friable; few very dark brown (10YR 2/2) oxides; slightly acid.

The A horizon ranges from 8 to 13 inches in thickness. It is black (10YR 2/1) or very dark grayish brown (10YR 3/2). Content of clay in the B horizon is as much as 40 to 44 percent. The depth to the C horizon is typically about 52 inches but ranges from 40 to more than 60 inches.

Grundy soils are associated with Haig soils and formed in loess as have Haig, Givin, and Mahaska soils. They are browner in the upper part of the B horizon than Haig soils, are higher in content of clay in the B2 horizon than Mahaska soils and Givin soils, and have a thicker A1 horizon than Givin soils.

The Grundy soils in Mahaska County are lower in content of clay in the subsoil than is typical for the series, but this does not significantly affect their use and management.

Grundy silty clay loam, 2 to 5 percent slopes (364B).—This soil has smooth convex slopes and is on uplands along the edges of broad divides and near the heads of drainageways. Areas are generally rather long and narrow, have irregular boundaries, and are 20 to 40 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of Mahaska, Otley, and Weller soils. These included areas make up 20 percent of the mapping unit.

Runoff is slow to medium on this soil. Drainage is needed in some places for timely farming operations. The surface layer is generally friable and is moderately easy to till. Tilth is good.

This soil is well suited to corn, soybeans, and hay. It is generally used for crops. Capability unit IIe-3; woodland suitability group 4w1.

Grundy silty clay loam, 5 to 9 percent slopes, moderately eroded (364C2).—This soil is on convex uplands, generally on the edges of upland divides and near the heads of waterways. Areas are generally elongated, have irregular boundaries, and are 20 to more than 40 acres in size.

This soil has a profile similar to that described as representative for the series, but the surface layer is thinner and depth to the maximum clay in the subsoil is less.

Included with this soil in mapping are small areas of Otley and Weller soils. These make up to 20 percent of the mapping unit.

Runoff is medium on this soil. The hazard of water erosion is moderate. The surface layer is generally friable and is moderately easy to till. Tilth is good.

This soil is moderately suited to corn, soybeans, and hay. Most areas are used for crops. Capability unit IIIe-3; woodland suitability group 4w1.

Haig Series

The Haig series consists of deep, poorly drained soils that formed in loess. These nearly level soils are on broad upland divides. Slopes are less than 2 percent. The native vegetation was grass and sedges.

In a representative profile the surface layer is 14 inches thick. It is black heavy silt loam in the upper part and black light silty clay loam in the lower part. The subsoil extends to a depth of about 54 inches. It is very dark gray heavy silty clay loam in the upper part, grayish-brown or olive-gray silty clay in the middle, and mottled grayish-brown and yellowish-brown silty clay loam in the lower part. The

middle part of the subsoil has mottles of yellowish brown and gray and the middle and lower parts are gleyed and have common, soft, dark-colored oxides.

Available water capacity is high in these soils. Permeability is slow to very slow. The surface layer is generally slightly acid unless it has been limed and is high in content of organic matter. The subsoil is low in available phosphorus and potassium.

Haig soils are wet in spring and need drainage to make timely farming operations possible. They are moderately well suited to row crops and are used intensively for this purpose where adequate drainage is provided.

Representative profile of Haig silt loam, 0 to 2 percent slopes, in a cultivated area 45 feet east and 63 feet north of the SW. corner of SE¼SW¼ sec. 31, T. 74, R. 17 W.:

Ap—0 to 10 inches, black (10YR 2/1) heavy silt loam, very dark gray (10YR 3/1) when dry; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A12—10 to 14 inches, black (10YR 2/1) light silty clay loam; weak, medium, subangular blocky structure that parts to weak, fine, granular; friable; neutral; clear, smooth boundary.

B1—14 to 23 inches, very dark gray (10YR 3/1) heavy silty clay loam; moderate, fine, granular structure; firm; medium acid; gradual, smooth boundary.

B21tg—23 to 29 inches, grayish-brown (2.5Y 5/2) silty clay; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; moderately thick, continuous, black (10YR 2/1) clay films; common, fine, strong-brown oxides; medium acid; gradual, smooth boundary.

B22tg—29 to 43 inches, olive-gray (5Y 5/2) silty clay; common, fine, prominent mottles of yellowish brown (10YR 5/6); moderate, medium, prismatic structure that parts to moderate, fine, subangular blocky; firm; thick, continuous, very dark gray (10YR 3/1) clay films; common, fine, strong-brown oxides; medium acid; diffused, smooth boundary.

B3tg—43 to 54 inches, mottled, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) silty clay loam; weak, medium, prismatic structure; firm; thin, discontinuous clay films and common dark flows; common, fine, strong-brown oxides; medium acid.

The A horizon ranges in thickness from 12 to 16 inches. It is typically heavy silt loam, but it is light silty clay loam in places. In the B2t horizon the maximum content of clay is 42 to 46 percent. Depth to the C horizon is generally about 55 inches but ranges from 50 to more than 60 inches.

Haig soils are associated with the Grundy soils and formed in loess material similar to that in which the Grundy, Rubio, and Taintor soils formed. They have a grayer B2t horizon than Grundy soils, are higher in content of clay in the B2 horizon than Taintor and Rubio soils, and have a thicker A1 horizon than Rubio soils.

Haig silt loam, 0 to 2 percent slopes (362).—This soil is on broad upland divides in the southwest part of the county. Areas of this soil are generally long and narrow, have irregular boundaries, and are 40 to more than 80 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of Grundy and Taintor soils. These make up as much as 15 percent of the mapping unit.

Runoff is very slow on this soil. In wet seasons water remains on the surface in places. Drainage of this soil is needed for crop growth. The surface layer is friable. In places where this soil is worked when it is too wet, soil compaction becomes a problem. Under proper moisture conditions tilth is good and the soil is moderately easy to till.

This soil is well suited to and is used intensively for corn, soybeans, and hay where adequate drainage is provided. Capability unit IIw-1; woodland suitability group 5w3.

Hedrick Series

The Hedrick series consists of deep, moderately well drained soils that formed in grayish loess. These soils have short, convex slopes and are on uplands. Slopes are 2 to 18 percent. The native vegetation was trees.

In a representative profile the surface layer is very dark grayish-brown silt loam 8 inches thick. Where these soils have been cultivated, the subsurface layer has been mixed into the surface layer. The subsoil extends to a depth of 53 inches. It is dark-brown silty clay loam to a depth of 15 inches. Between depths of 15 and 32 inches it changes from mixed brown and gray silty clay loam that has clay films and gray silt coatings on ped faces to light brownish-gray light silty clay loam. The latter has mottles of strong brown and has clay films and black organic stains in root channels. Between depths of 32 and 53 inches is light olive-gray light silty clay loam that has mottles of strong brown and clay films. Dark clay and organic flows are in the root channels. The underlying material is light olive-gray light silty clay loam and light brownish-gray silt loam. It has mottles of strong brown and brownish yellow. A few organic flows are in root channels of the underlying material.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is generally medium acid unless it has been limed and is low in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium.

Hedrick soils are used for row crops, hay, pasture, and trees.

Representative profile of Hedrick silt loam, 5 to 9 percent slopes, in a cultivated area 570 feet north and 440 feet west of the SE. corner of SW¼ sec. 30, T. 77 N., R. 17 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; common gray patches and gray silt coatings in lower 3 inches; neutral; clear, smooth boundary.

B21t—8 to 15 inches, dark-brown (10YR 4/3) silty clay loam; ped faces very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3); moderate, very fine, angular blocky structure; firm; common roots; thin, discontinuous clay films; thin, discontinuous gray silt coatings on ped faces; neutral; clear, smooth boundary.

B22t—15 to 23 inches, mottled brown (10YR 5/3), strong-brown (7.5YR 5/6), and gray (10YR 6/1) silty clay loam; moderate, fine, angular blocky structure; firm; thin, discontinuous dark grayish-brown (10YR 4/2) clay films; common discontinuous gray silt coatings on ped faces; medium acid; gradual, smooth boundary.

B23t—23 to 32 inches, light brownish-gray (2.5Y 6/2) light silty clay loam; dark-brown (10YR 4/3) coatings on ped faces; common, medium, prominent mottles of strong brown (7.5YR 5/6); moderate, medium, subangular blocky structure; firm; thin, continuous clay films and black (10YR 2/1) organic stains in root channels; medium acid; gradual, smooth boundary.

B3t—32 to 53 inches, light olive-gray (5Y 6/2) light silty clay loam; many, coarse, prominent mottles of strong brown (7.5YR 5/6); weak, coarse, prismatic structure that parts to weak, coarse, angular blocky; firm; thick, continuous dark grayish-brown (10YR 4/2) clay films; black (10YR 2/1) clay flows in root channels; slightly acid; gradual, smooth boundary.

C1g—53 to 63 inches, light olive-gray (5Y 6/2) light silty clay loam; common, medium, prominent mottles of strong brown (7.5Y 5/6); weak, coarse, prismatic structure; firm; common dark clay flows and organic flows in root channels; neutral; diffused, smooth boundary.

C2g—63 to 80 inches, light brownish-gray (2.5Y 6/2) heavy silt loam; common, coarse, prominent mottles of strong brown (7.5YR 5/8); massive; friable; organic flows in root channels; mildly alkaline.

In uncultivated areas where the soils are uneroded the A1 horizon ranges from 6 to 9 inches in thickness and the A2 horizon from 2 to 6 inches in thickness. The A horizon is typically silt loam but ranges to light silty clay loam in places. The B1 horizon is light or medium silty clay loam. Thin clay films and grayish-colored silt coatings are typical but are not evident in some places. The maximum content of clay in the B2t horizon is typically about 35 to 37 percent. Matrix colors of the B23t and B3t horizons range from 10YR to 5Y in hue. Value is 5 or 6, and chroma is 1 or 2. Reaction is medium to strongly acid in the most acid parts of the solum.

Hedrick soils are associated with the Clinton, Downs, Ladoga, and Nira soils. They have a thinner A1 horizon than Nira soils and a grayer B2 horizon below a depth of 24 inches than Downs, Clinton, and Ladoga soils.

Hedrick silt loam, 2 to 5 percent slopes (571B).—This soil has short slopes and is on uplands. It is commonly at the heads of drainageways. Areas of this soil are generally somewhat elongated, have irregular boundaries, and are 10 to 20 acres in size.

Included with this soil in mapping are small areas of Clinton and Ladoga soils.

Runoff is medium on this soil. The hazard of erosion is moderate. The surface layer is low in content of organic matter. It is friable and easy to till.

Under proper management this soil is well suited to corn, soybeans, hay, and pasture. Capability unit IIe-1; woodland suitability group 1o1.

Hedrick silt loam, 5 to 9 percent slopes (571C).—This soil has short, convex slopes and is on uplands. It is commonly at the heads of drainageways and on side slopes between waterways just above the seep line. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 10 to 20 acres in size. This soil has the profile described as representative for the Hedrick series.

Included with this soil in mapping are small areas of Clinton and Ladoga and moderately eroded Hedrick soils.

Runoff is medium on this soil. The hazard of water erosion is moderate. The surface layer is low in content of organic matter, is friable, and is easy to till. Tilth is good.

Under proper management this soil is moderately well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Hedrick silt loam, 5 to 9 percent slopes, moderately eroded (571C2).—This soil has short, convex slopes and is on uplands. It is generally around the heads of drainageways and on side slopes between drainageways above the seep line. The areas are generally 10 to 20 acres in size.

This soil has a profile similar to that described as representative for the Hedrick series, except the surface layer is thinner, and the point where the maximum amount of clay is in the subsoil is not so deep.

Included with this soil in mapping are small areas of Clinton soils. Also included are small areas of severely eroded Hedrick soils that are shown on the soil map by the symbol for severe erosion.

Runoff is medium on this soil. The hazard of water erosion is moderate. The surface layer is low in content of organic matter, is friable, and is easy to till. Tilth is good.

Under proper management this soil is moderately well suited to corn and soybeans. It is well suited to hay or pasture. Capability unit IIIe-1; woodland suitability group 1o1.

Hedrick silt loam, 9 to 14 percent slopes, moderately eroded (571D2).—This soil has short, convex slopes and is on uplands. It is generally around the heads of drainageways and on side slopes between drainageways above the seep line. It generally formed in deoxidized loess over clay, but in some places the loess is underlain by shale. The areas are generally 10 to 30 acres in size.

This soil has a profile similar to that described as representative for the Hedrick series, except the surface layer is thinner, and the point where the maximum amount of clay is in the subsoil is not so deep.

Included with this soil in mapping are small areas of Clinton soil. Also included are small areas of severely eroded Hedrick soil that are shown on the soil map by the symbol for severe erosion.

Runoff is rapid on this soil. The hazard of water erosion is severe. The surface layer is low in content of organic matter, is friable, and is easy to till. Tilth is good.

Under proper management this soil is moderately well suited to corn and soybeans. It is well suited to hay or pasture. Capability unit IIIe-2; woodland suitability group 1o1.

Hedrick silt loam, 14 to 18 percent slopes, moderately eroded (571E2).—This soil has short, convex slopes and is on uplands. It is generally around the heads of drainageways and on side slopes between drainageways above the seep line. It generally formed in deoxidized loess over clay, but in some places the loess is underlain by shale. The areas are generally 10 to 30 acres in size.

This soil has a profile similar to that described as representative for the Hedrick series, except the surface layer is thinner, and the point where the maximum amount of clay is in the subsoil is not so deep.

Included with this soil in mapping are small areas of Clinton soil. Also included are small areas of severely eroded Hedrick soils that are shown on the soil map by the symbol for severe erosion.

Runoff is rapid on this soil. The hazard of water erosion is severe. The surface layer is low in content of organic matter and is friable. Tilth is good.

This soil is poorly suited to corn and soybeans. It is well suited to pasture or trees. Capability unit IVe-1; woodland suitability group 1o1.

Humeston Series

The Humeston series consists of deep, poorly drained to very poorly drained soils that formed in clayey alluvium. These soils are on nearly flat or slightly depressional slack water areas on first or second bottom lands. Slopes are 0 to 2 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is black heavy silt loam 9 inches thick. The subsurface layer is dark-gray heavy silt loam 11 inches thick. The subsoil extends to a depth of 80 inches. It is black silty clay in the upper 40 inches and dark-gray heavy silty clay loam that has mottles of yellowish brown in the lower part.

Available water capacity is high in these soils. Permeability is moderately slow in upper part of the soil and very slow in the lower part. The surface layer is generally slightly acid unless it has been limed and is high in content of organic matter. The subsoil is medium to low in available phosphorus and very low in available potassium.

Humeston soils are generally wet in spring, and water may stand on them temporarily. Where the surface is drained, these soils are moderately well suited to row crops and hay.

Representative profile of Humeston silt loam, 0 to 2 percent slopes, in a cultivated area 500 feet north and 40 feet west

of the SE. corner of SW¼ sec. 3, T. 74 N., R. 17 W.:

Ap—0 to 5 inches, black (10YR 2/1) heavy silt loam, dark grayish brown (10YR 4/2) when dry; moderate, medium and fine, granular structure; friable; many roots; slightly acid; abrupt, smooth boundary.

A12—5 to 9 inches, black (10YR 2/1) heavy silt loam; few, fine, distinct mottles of yellowish brown (10YR 5/4); dark grayish brown (10YR 4/2) when dry; moderate, medium and fine, platy structure; friable; common roots; slightly acid; clear, smooth boundary.

A2—9 to 20 inches, dark-gray (10YR 4/1) heavy silt loam, light gray (10YR 6/1) when dry; moderate, fine, platy structure; friable; nearly continuous gray silt coatings on ped faces; slightly acid; clear, smooth boundary.

B1—20 to 23 inches, very dark gray (10YR 3/1) heavy silty clay loam; moderate, fine, subangular blocky structure; firm; common gray silt coatings on ped faces; strongly acid; clear, smooth boundary.

B21tg—23 to 47 inches, black (10YR 2/1) silty clay; weak, fine, prismatic structure that parts to moderate, medium and fine, subangular blocky; very firm; few, thin, discontinuous clay films; strongly acid; gradual, smooth boundary.

B22tg—47 to 60 inches, very dark gray (10YR 3/1) silty clay; few, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; very firm; medium acid; gradual, smooth boundary.

B3tg—60 to 80 inches, dark-gray (10YR 4/1) heavy silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; firm; few dark stains in root channels; medium acid.

The A1 horizon ranges from 6 to 10 inches in thickness. It is black (10YR 2/1) or very dark gray (10YR 3/1). The A2 horizon ranges from 10 to 15 inches in thickness. The B2tg horizon is black (N 2/0) to very dark gray (10YR 3/1). The maximum content of clay in the B2tg horizon ranges from 40 to 48 percent.

Humeston soils are associated with Bremer, Tuskeego, and Vesser soils. They have a higher content of clay in the B2 horizon than the Vesser soils. Humeston soils have a darker colored B horizon than Tuskeego soils. They have a thinner A1 horizon than Bremer soils, and Bremer soils do not have an A2 horizon.

Humeston silt loam, 0 to 2 percent slopes (269).—This soil has nearly level or slightly concave slopes and is in slack water areas of bottom lands. Areas are irregular in shape and are generally 5 to 15 acres in size. This soil has the profile described as representative for the Humeston series.

Included with this soil in mapping are small areas of Colo and Zook soils.

Runoff is very slow on this soil, and water often stands on the surface during wet periods. The surface layer is friable. Tilth is good.

Where adequate surface drainage is provided, this soil is moderately well suited to corn, soybeans, and hay. It is well suited to pasture. Capability unit IIIw-2; woodland suitability group 5w3.

Huntsville Series

The Huntsville series consists of deep, moderately well drained and well drained soils that formed in silty alluvium. They are on nearly level flood plains in the valleys of the larger streams in the county. Slopes are 0 to 2 percent. The native vegetation was grass.

The surface layer is silt loam 24 inches thick and is black in the upper part and very dark brown in the lower part. The subsoil extends to a depth of 45 inches. It is very dark grayish-brown heavy silt loam in the upper part and brown heavy silt loam that has organic stains of very dark grayish brown in the lower part. The underlying material, to a depth of 65 inches, is brown light clay loam that has ½-inch to 3-inch horizontal bands of dark yellowish-brown sandy loam or loamy sand. Below this is brown silty clay loam and light brownish-gray silt loam.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is high in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium.

Huntsville soils are subject to flooding in spring. They have a soil blowing hazard in winter and early in spring if they are unprotected. These soils are well suited to row crops and hay.

Representative profile of Huntsville silt loam, 0 to 2 percent slopes, in a cultivated area 380 feet north of fence corner at the NW. corner of the SE¼SE¼ sec. 21, T. 76 N, R. 16 W.:

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; many roots; neutral; abrupt, smooth boundary.

A12—8 to 17 inches, very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; common roots; medium acid; clear, smooth boundary.

A13—17 to 24 inches, very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, medium, granular structure; friable; thin, discontinuous gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B1—24 to 37 inches, very dark grayish brown (10YR 3/2) heavy silt loam, dark brown (10YR 3/3) when crushed; weak, medium, granular structure; friable; discontinuous gray silt coatings on ped faces; a few single-grained sand particles visible; medium acid; clear, smooth boundary.

B2—37 to 45 inches, brown (10YR 4/3) heavy silt loam; common patchy, very dark grayish-brown (10YR 3/2) organic stains; weak, medium, granular structure; friable; medium acid; gradual, smooth boundary.

C1—45 to 65 inches, brown (10YR 5/3) light clay loam; massive; friable to loose; ½- to 1-inch bands of dark yellowish-brown (10YR 4/4) sandy loam and 2- to 3-inch bands of dark yellowish-brown (10YR 4/4) loamy sand; slightly acid; clear, smooth boundary.

C2—65 to 73 inches, brown (10YR 5/3) silty clay loam; few, fine, distinct mottles of grayish brown (2.5Y 5/2); massive; firm; neutral; clear, smooth boundary.

C3—73 to 92 inches, light brownish-gray (2.5Y 6/2) silt loam; common, fine and medium, distinct mottles of brown (10YR 5/3); massive; friable; common fine manganese-iron oxides; slightly acid.

The A horizon ranges from 24 to more than 40 inches in thickness and is black (10YR 2/1) to very dark grayish brown (10YR 3/2). In places where the A horizon is about 24 inches thick, a very weakly developed B horizon is present.

Huntsville soils are associated with Ely, Judson, Kennebec, and Wiota soils. Huntsville soils are browner below a depth of 24 inches than Kennebec and Ely soils. They are lower in content of clay than Judson and Wiota soils.

Huntsville silt loam, 0 to 2 percent slopes (98).—This soil is on flood plains along the larger streams in the county. Areas are generally irregularly shaped and 5 to 20 acres in size. This soil has the profile described as representative for the Huntsville series.

Included with this soil in mapping are areas where 3 to 7 inches of grayish-brown silty overwash is on the surface. Also included are small areas of Landes, Nodaway, and Kennebec soils.

Runoff is slow on this soil. Wetness is a problem in spring because of temporary overflow during heavy rains, unless the soil is protected against flooding. The surface layer is friable and is easy to till. Tilth is good.

This soil is well suited to and is used intensively for corn, soybeans, and hay. Capability unit I-2; woodland suitability group 5w2.

Judson Series

The Judson series consists of deep, moderately well drained to well drained soils that formed in alluvium washed from adjacent soils that developed in loess on uplands. Judson soils are on slightly concave foot slopes and on alluvial fans. Slopes are 2 to 9 percent. The native vegetation was grass.

In a representative profile the surface layer is very dark brown silty clay loam about 17 inches thick. The subsurface layer is very dark grayish-brown silty clay loam about 7 inches thick. The subsoil extends to a depth of about 74 inches. It is dark-brown silty clay loam in the upper part; brown silty clay loam in the middle; and mottled, yellowish-brown and light-gray silty clay loam in the lower part. The underlying material is mottled, light-gray and yellowish-brown silt loam. Soft accumulations of iron and manganese are in the lower part of the subsoil and in the underlying material.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is neutral to slightly acid and is high in content of organic matter. The subsoil is low in available phosphorus and potassium.

These soils are subject to flooding, and silty sediment deposits are on their surface. They are also subject to erosion during hard rains, but erosion is not so great a hazard to young plants as is the accumulation of silty material.

Judson soils are well suited to row crops. Areas are generally so small that they are managed with adjacent soils.

Representative profile of Judson silty clay loam, 2 to 5 percent slopes, in a meadow 175 feet north and 20 feet east of the SW. corner of the SE¼SW¼ sec. 25, T. 75 N., R. 17 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) light silty clay loam, grayish brown (10YR 5/2) when dry; weak, fine and medium, granular structure; friable; neutral; clear, smooth boundary.

A12—8 to 17 inches, very dark brown (10YR 2/2) light silty clay loam, grayish brown (10YR 5/2) when dry; weak, medium and coarse, granular structure; friable; slightly acid; clear, smooth boundary.

A3—17 to 24 inches, very dark grayish brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) when dry; moderate, medium and coarse, granular structure; friable; slightly acid; clear, smooth boundary.

B1—24 to 30 inches, dark-brown (10YR 3/3) silty clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces, brown (10YR 5/3) when dry; weak, medium, prismatic structure that parts to moderate, fine, subangular blocky; friable; slightly acid; gradual, smooth boundary.

B21t—30 to 42 inches, brown (10YR 4/3) light silty clay loam, pale brown (10YR 6/3) when dry; weak, coarse, prismatic structure that parts to moderate, fine, subangular blocky; friable; thin, patchy clay films; common discontinuous gray coatings on ped faces; few scattered organic stains; few, fine, faint, yellowish-brown (10YR 5/4) and few, fine, distinct, light brownish-gray (10YR 6/2) coatings on ped faces; medium acid; gradual, smooth boundary.

B22t—42 to 47 inches, brown (10YR 4/3) light silty clay loam, brown (10YR 5/3) when crushed and pale brown (10YR 6/3) when dry; weak, coarse, prismatic structure that parts to weak, medium, subangular blocky; friable; common, distinct, gray coatings on ped faces; thin, patchy clay films and organic stains; common, medium, faint, yellowish-brown (10YR 5/4) and common, medium, distinct, light brownish-gray (10YR 6/2) coatings on ped faces; slightly acid; gradual, smooth boundary.

B3t—47 to 74 inches, mottled, yellowish-brown (10YR 5/6), light-gray (10YR 7/1), and yellowish-brown (10YR 5/4) light silty clay loam; weak, coarse, prismatic structure that parts to weak, coarse, subangular blocky; friable; thin, patchy clay films and organic stains; soft iron and manganese concretions; neutral; diffused, smooth boundary.

C—74 to 96 inches, mottled, light-gray (10YR 7/1) and yellowish-brown (10YR 5/6 and 5/4) heavy silt loam; massive; friable; soft iron and manganese accumulations; neutral.

The A horizon is silt loam or light silty clay loam that ranges from 20 to 30 inches in thickness. The B horizon is brown (10YR 4/3) or dark brown (10YR 3/3) in the upper part.

Judson soils are associated with Ely, Nevin, and Wiota soils. The upper part of the B horizon of Judson soils is browner than that of Ely soils. Judson soils do not have as great an increase in content of clay from the A to the B horizon as Wiota and Nevin soils.

Judson silty clay loam, 2 to 5 percent slopes (8B).—This soil is on slightly concave foot slopes and on alluvial fans (fig. 10) in valleys throughout the county. Areas are generally 5 to 30 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of Otley, Wiota, Ely, and Colo soils. Otley silty clay loam is at a higher elevation, and Colo silty clay loam is along the creek bottom. Also included are a few areas that have from 5 to 12 inches of recently deposited material on the surface. These silty deposits are generally lighter in color and lower in content of organic matter than the typical surface layer.

Runoff is slow to medium on this soil. Runoff water from uplands causes slight erosion and wetness for short periods in spring. The surface layer is friable and easy to till. Tilth is good.

Judson soil is used intensively for and is well suited to corn and soybeans. Capability unit IIe-2; woodland suitability group 1o1.

Judson silty clay loam, 5 to 9 percent slopes (8C).—This soil is on slightly concave foot slopes and on alluvial fans along drainageways throughout the county. Areas are often rather long and narrow and 10 to 25 acres in size.

Included with this soil in mapping are small areas of Otley, Ladoga, Fayette, and Olmitz soils. Also included are small areas of Judson soil with 7 to 18 inches of silty overwash material on the surface. Accumulations of silty materials in the spring cause damage to newly planted crops. This soil is generally lower in content of organic matter and poorer in tilth than the typical Judson soil.

Runoff is medium on this soil. The soil loss by erosion is

***Figure 10.*—Typical area of Judson silty clay loam, 2 to 5 percent slopes.**

offset by the accumulation of soil material from the adjacent soils upslope from the Judson soil. The surface layer is friable and easy to work.

This soil is used intensively for and is well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Kennebec Series

The Kennebec series consists of deep, dark-colored, moderately well drained soils that formed in silty alluvium. These soils are on the nearly level flood plains of the larger streams in the county. Slopes are 0 to 2 percent. The native vegetation was grass.

The surface layer is silt loam 49 inches thick. It is black in the upper part and very dark brown in the lower part. The underlying material is dark grayish-brown to brown silt loam.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is neutral to slightly acid and is high in content of organic matter. The underlying material is low in available phosphorus and low or very low in available potassium.

Kennebec soils are subject to some overflow unless they are protected. These soils are well suited to and used intensively for row crops.

Representative profile of Kennebec silt loam, 0 to 2 percent slopes, in a cultivated area 10 feet south and 160 feet east of the NW. corner of SE¼NE¼ sec. 35, T. 74 N., R. 16 W.:

Ap—0 to 12 inches, black (10YR 2/1) heavy silt loam, dark grayish brown (10YR 4/2) when dry; weak, medium, granular structure; friable; neutral; clear, smooth boundary.

A11—12 to 23 inches, black (10YR 2/1) heavy silt loam, very dark gray (10YR 3/1) when dry; moderate, fine, granular structure; friable; neutral; clear, smooth boundary.

A12—23 to 29 inches, very dark brown (10YR 2/2) heavy silt loam; weak, medium, granular structure; friable; slightly acid; gradual, smooth boundary.

A13—29 to 49 inches, average of 70 percent very dark brown (10YR 2/2) and 30 percent very dark grayish-brown (10YR 3/2) heavy silt loam, proportion shifting with depth to an increase in very dark grayish brown (10YR 3/2) and a decrease in very dark brown (10YR 2/2); weak, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

AC—49 to 59 inches, dark grayish-brown (10YR 4/2) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; diffused, smooth boundary.

C—59 to 70 inches, brown (10YR 4/3) light silty clay loam; massive; friable; neutral.

The A1 horizon is light silty clay loam to silt loam that ranges from 36 to more than 50 inches in thickness. It is black (10YR 2/1) or very dark brown (10YR 2/2) at the surface. Content of clay is 24 to 30 percent. Mottles of brown (10YR 4/3) are present in places below a depth of 36 inches. The C horizon is very dark grayish brown (10YR 3/2) to brown (10YR 5/3). It ranges from silt loam to silty clay loam.

Kennebec soils are associated with Amana, Colo, Nodaway, and Ossian soils. Kennebec soils are darker colored and less stratified than Nodaway soils. They are not as high in content of clay as Colo soils. Kennebec soils have a much thicker dark A horizon than Amana and Ossian soils.

Kennebec silt loam, 0 to 2 percent slopes (212).—This soil is on flood plains in areas that are somewhat parallel to the larger streams in the county. Areas have irregularly shaped boundaries and are generally 10 to more than 40 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are areas of a similar soil that has a few layers of lighter colored silty sediments. Also included are small areas of Kennebec soil that has brownish sandy sediment 2 to 5 inches thick on the surface. A few areas that have sandy accumulations 5 to 10 inches thick on the surface are shown on the map by a special symbol. Small areas of Colo and Zook soils are also included.

Runoff is slow on this soil. The surface layer is friable and easy to till. Tilth is good. In some places wetness caused by overflow water during wet seasons delays farming operations.

This soil is well suited to corn, soybeans, and hay. Capability unit I-2; woodland suitability group 5w2.

Keswick Series

The Keswick series consists of deep, moderately well drained soils on uplands. These soils formed mostly in weathered reddish glacial till, but the surface and subsurface layers formed in loess or sediment. Slopes are convex and range from 5 to 18 percent. The native vegetation was trees.

The surface layer is thin, very dark gray loam about 5 inches thick. The subsurface layer, about 3 inches thick, is brown loam that has gray silt coatings on ped faces. The subsoil has a pebble band at a depth of 14 inches. Above the band the subsoil is brown light clay loam that has gray silt coatings on the ped faces. Below it the subsoil, to a depth of about 23 inches, is brown clay that has mottles of yellowish red and grayish brown. Sand particles are common. Below a depth of 23 inches, the subsoil is strong-brown or yellowish-brown heavy clay loam that has mottles of yellowish red, light brownish gray, gray, and brown. The lower part of the subsoil, between depths of 49 and 63 inches, is mottled, light yellowish-brown and light brownish-gray heavy clay loam.

Available water capacity is high in these soils. Permeability is slow. The surface layer is medium acid unless it has been limed, and it is low in content of organic matter. The subsoil is very low in available phosphorus and potassium. Keswick soils are seasonably wet and seepy in areas near their boundary where soils upslope formed in more permeable loess.

Keswick soils are poorly suited to row crops, moderately well suited to hay, and well suited to pasture or trees. They are most commonly used for pasture.

Representative profile of Keswick loam in a wooded and grassy area of Lindley-Keswick complex, 14 to 18 percent slopes, moderately eroded; 1,250 feet west and 2,000 feet north of the SW. corner of sec. 5, T. 77 N., R. 15 W.:

A1—0 to 5 inches, very dark gray (10YR 3/1) loam, light gray (10YR 6/1) when dry; medium, very fine, granular structure; friable; medium acid; abrupt, smooth boundary.

A2—5 to 8 inches, brown (10YR 5/3) loam; dark grayish-brown (10YR 4/2) coatings on ped faces, light gray (10YR 7/2) when dry; moderate, coarse, platy structure that parts to weak, very fine, subangular blocky; friable; many light-gray (10YR 7/1) silt grains on ped faces; medium acid; abrupt, smooth boundary.

B1—8 to 14 inches, brown (7.5YR 4/4) light clay loam; weak, medium, subangular structure that parts to strong, fine, blocky; friable; many gray silt coatings on ped faces; pebble band at a depth of 14 inches; medium acid; clear, smooth boundary.

IIB21t—14 to 23 inches, brown (7.5YR 4/4) clay; common, fine, distinct, yellowish-red (5YR 4/6 and 4/8) and few, fine, distinct, grayish-brown (2.5Y 5/2) mottles; moderate, fine, subangular blocky structure; very firm; discontinuous thick clay films; common particles of coarse sand and few pebbles; strongly acid; gradual boundary.

IIB22t—23 to 32 inches, strong-brown (7.5YR 5/6) heavy clay

loam; few, fine, distinct mottles of yellowish red (5YR 5/6) and light brownish gray (2.5Y 6/2); moderate, fine, subangular blocky structure; very firm; discontinuous thick clay films; common roots; few pores; strongly acid; gradual, smooth boundary.

IIB2t—32 to 42 inches, yellowish-brown (10YR 5/6) heavy clay loam; common, medium, distinct mottles of gray (10YR 6/1) and brown (7.5YR 5/4); weak, fine, prismatic structure that parts to weak, medium, subangular blocky; very firm; discontinuous thick clay films; very few pores; common, fine, soft dark oxides; neutral; diffused, smooth boundary.

IIB31t—42 to 49 inches, brownish-yellow (10YR 6/6) heavy clay loam; brown (10YR 5/3) coatings on ped faces; few, fine, distinct mottles of light olive gray (5Y 6/2); weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; discontinuous thin clay films; few soft dark oxides; neutral; diffused, smooth boundary.

IIB32t—49 to 63 inches, mottled light yellowish-brown and light brownish-gray (2.5Y 6/2) heavy clay loam; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; discontinuous thin clay films; few roots to a depth of 60 inches; common, medium, soft black oxides; few lime concretions; neutral.

The A1 horizon, where it has not been cultivated, ranges in thickness from 3 to 6 inches and in color from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). The A2 horizon ranges in thickness from 3 to 6 inches and in color from brown (10YR 5/3) to grayish brown (10YR 5/2). The IIB2t horizon ranges in texture from heavy clay loam to clay. Depth to the C horizon ranges from 50 to 70 inches.

Keswick soils are associated with Clinton soils and formed in material similar to that in which Armstrong soils formed. They have a thinner A1 horizon than Armstrong soils. Keswick soils formed in glacial till, and Clinton soils formed in loess.

The Keswick soils in this county are mapped only in a complex with soils of the Lindley series.

Ladoga Series

The Ladoga series consists of deep, moderately well drained soils that formed in silty loess. These soils are in uplands on convex ridgetops, convex side slopes, and nose slopes along the major rivers and on high stream benches. Slopes are 2 to 14 percent. The native vegetation was mixed prairie grass and trees.

In a representative profile the surface layer is very dark brown silt loam 6 inches thick. The subsurface layer is dark grayish-brown silt loam 4 inches thick. This material becomes distinctly light colored when dry. The subsoil is medium and heavy silty clay loam that extends to a depth of 56 inches. It is brown in the upper part and dark yellowish brown in the lower part.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is moderate in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium.

These soils are intensively cropped. Corn is the major crop on the less sloping areas. Ladoga soils that have slopes of 14 to 18 percent frequently are used for meadow crops or are left in permanent pasture.

Representative profile of Ladoga silt loam, 2 to 5 percent slopes, in a cultivated area 475 feet east and 500 feet south of the NW. corner of SW¼ sec. 23, T. 75 N., R. 17 W.:

Ap—0 to 6 inches, very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—6 to 10 inches, dark grayish-brown (10YR 4/2) heavy silt loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; grayish brown (10YR 5/2) when dry; weak, medium, platy structure that parts to moderate, fine, subangular blocky; friable; few, discontinuous, gray silt coatings on ped faces; slightly acid; clear, smooth boundary.

B1—10 to 17 inches, brown (10YR 4/3) silty clay loam; dark-brown (10YR 3/3) coatings on ped faces; strong, fine and very fine, angular blocky structure; friable; common, discontinuous, gray silt coatings on ped faces; slightly acid; gradual, smooth boundary.

B21t—17 to 26 inches, dark yellowish-brown (10YR 4/4) heavy silty clay loam; dark-brown (10YR 3/3) coatings on ped faces; moderate, medium and fine, angular and subangular blocky structure; firm; few, discontinuous, gray silt coatings on ped faces; thin, discontinuous clay films; medium acid; gradual, smooth boundary.

B22t—26 to 37 inches, dark yellowish-brown (10YR 4/4) medium silty clay loam; dark-brown (10YR 3/3) coatings on ped faces; few fine mottles of grayish brown (10YR 5/2) and yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; thin, continuous clay films of dark brown (10YR 3/3) on prism faces; few soft accumulations of iron-manganese oxides; medium acid; gradual, smooth boundary.

B3t—37 to 56 inches, dark yellowish-brown (10YR 4/4) silty clay loam; brown (10YR 4/3) coatings on ped faces; common, fine, faint mottles of dark grayish brown (10YR 4/2) and few distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to weak, medium, subangular blocky; firm; thin, discontinuous clay films along prism faces; slightly acid.

The A1 horizon, where it is not eroded, ranges from 6 to 10 inches in thickness. It is very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The A2 horizon where present is 2 to 5 inches thick. The B2t horizon ranges from brown (10YR 4/3) to dark yellowish brown (10YR 4/4). In places grayish mottles are in the lower part of the B horizon. They generally increase in abundance and size with depth. In some places light-gray silt coatings are distinctly evident throughout the B horizon. The B2t horizon ranges from medium silty clay loam to light silty clay that is 35 to 42 percent clay. Ladoga soils are leached to a depth of 60 inches or more. Reaction is medium acid to strongly acid in the most acid part.

Ladoga soils are associated with the Clinton, Hedrick, Nira, and Otley soils. They have a thinner, less clayey A1 horizon than Otley soils, and they have a grayish A2 horizon where they are not eroded. Gray silt coatings are in the B1 horizon of Ladoga soils but not in the B1 horizon of Otley soils. Ladoga soils have a thicker and darker A1 horizon and less distinct A2 horizon than Clinton soils. They are browner at a depth of 24 to 36 inches than Nira and Hedrick soils.

Ladoga silt loam, 2 to 5 percent slopes (76B).—This soil is on convex upland divides and side slopes. Areas are generally quite long and narrow, are often more than half a mile long and only a few hundred feet wide, and are generally 40 to 60 acres in size. This soil has the profile described as representative for the Ladoga series.

Included with this soil in mapping are small, nearly level areas that have a thicker surface layer than this Ladoga soil. At the heads of drainageways some areas have a mottled subsoil and are not so well drained. Also included, along narrow drainageways, are soils that have a thicker surface layer. A few sandy areas of Chelsea soils are included in mapping. These are shown on the map by the sand spot symbol.

Runoff is medium on this soil. Soil erosion and maintenance of soil fertility are the chief management concerns. This soil can be used intensively for row crops and is well suited to corn, soybeans, small grains, and forage crops. Capability unit IIe-1; woodland suitability group 1o1.

Ladoga silt loam, 5 to 9 percent slopes (76C).—This soil is on the edge of convex upland divides and on side slopes between waterways. In some areas the surface layer is slightly thinner, but the profile of this soil is otherwise similar to that described as representative of the series. Also,

along narrow drainageways the surface layer is darker colored and thicker. Areas are generally quite long and narrow, have irregular boundaries, and are generally 20 to more than 40 acres in size. They often extend horizontally for one-half mile or more but are only a few hundred feet wide.

Included with this soil in mapping in places are small areas of Nira and Hedrick soils at the heads of drainageways. Also included are small areas of gray and reddish weathered till that is seasonally wet and seepy. These are shown on the maps by special symbols. In addition to these areas, small seasonally wet and seepy spots of Clearfield soils are included in cove positions, and a few sandy areas of Chelsea soils, indicated on the map by a sand spot symbol, are included.

Runoff is medium on these soils. The hazard of water erosion is moderate. The surface layer is friable. Tilth is good.

This soil is moderately well suited to corn, soybeans, and hay if it is properly managed. Capability unit IIIe-1; woodland suitability group 1o1.

Ladoga silt loam, 5 to 9 percent slopes, moderately eroded (76C2).—This soil is on the edge of convex, narrow upland divides and on side slopes between waterways. Areas are generally quite long and narrow, have irregular boundaries, are often one-half mile or more long but only a few hundred feet wide. They are generally 20 to 40 acres in size.

This soil has a profile similar to that described as representative for the Ladoga series, but the surface layer of this soil is eroded and thinner. The surface layer is 4 to 7 inches in thickness and is light silty clay loam in some places.

Included with this soil in mapping are small areas of Hedrick and Nira soils in some places at the heads of drainageways. The surface layer is darker and thicker in the narrow drainageways than it is in other areas. Also included are severely eroded spots and small areas of seasonally wet and seepy gray and reddish weathered till. These are shown on the map by spot symbols. Small areas of the seasonally wet and seepy Clearfield soils are in cove positions. A few sandy areas of Chelsea soils, indicated on the map by a sand spot symbol, also are included in mapping.

Runoff is medium on this soil. The hazard of erosion is moderate. The plow layer is friable. The tilth depends upon the content of organic matter and clayey subsoil that has been mixed into the plow layer.

If this soil is properly managed it is moderately suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Ladoga silt loam, 9 to 14 percent slopes (76D).—This soil is in convex uplands that are downslope from other Ladoga soils. Areas are long and narrow and extend horizontally along hillsides and around nose slopes. These areas are generally 10 to 20 acres in size.

This soil has a profile similar to that described as representative for the Ladoga series, but the surface layer is only 6 inches thick. In cultivated areas part of the subsurface layer is included in the plow layer. The surface layer of this soil is about 6 inches thick, thinner than that in the profile described as representative for the Ladoga series. In wooded areas a thin layer of leaf litter is generally on the surface, and the surface layer is slightly thicker. The surface layer is thicker and darker along some narrow drainageways than it is in most other areas.

Included with this soil in mapping are few moderately eroded areas that are 1 to 3 acres in size. Small spots of seasonally wet and seepy gray and reddish weathered till are shown on the map by spot symbols. Also included in mapping are a few sandy areas of Chelsea soils. These are indicated on the map by a sand spot symbol.

Runoff is rapid on this soil. The hazard of erosion is moderate or severe.

If this soil is properly managed, it is moderately suited to corn, soybeans, and hay. Capability unit IIIe-2; woodland suitability group 1o1.

Ladoga silt loam, 9 to 14 percent slopes, moderately eroded (76D2).—This soil is on uplands and is downslope from other Ladoga soils. Slopes are convex. Areas are generally long and narrow, extend horizontally along hillsides and around nose slopes. They are 10 to 50 acres in size.

The surface layer of this eroded soil is thinner, lighter colored, and contains more clay than that in the profile described as representative for the Ladoga series. The surface layer is very dark grayish-brown or dark-brown silty clay loam 3 to 7 inches thick. In most places the original surface and subsurface layers have been mixed with some of the yellowish-brown subsoil by tillage. The surface layer is thicker and dark along the concave part of the drainageways that receives sediment from upslope.

Included with this soil in mapping are areas of severely eroded Ladoga soils and small spots of gray and reddish weathered till that are seasonally wet and seepy. These are shown on the map by a special symbol. Also included are few small areas of Chelsea, Gosport, and Gara soils.

Runoff is rapid on these soils. The hazard of water erosion is severe. The surface layer is friable, but the content of organic matter is low.

This soil is moderately well suited to corn and soybeans. It is well suited to hay or meadow. Capability unit IIIe-2; woodland suitability group 1o1.

Ladoga silt loam, benches, 2 to 5 percent slopes (T76B).—This soil is on convex loess-covered benches on river bottoms and on moderately wide high benches adjacent to wide river bottoms. The benches are underlain by alluvium at a depth of 10 to 15 feet. Areas are 5 to 15 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative for Ladoga series, except the total thickness of the surface and subsurface layers is generally 2 or 3 inches more, and the subsoil in many areas is medium silty clay loam.

Included with this soil in mapping are small areas of nearly level, somewhat poorly drained soils that have a grayer subsoil than this soil. Also included are a few sandy areas of Chelsea soils. These are indicated on the map by a sand spot symbol.

Runoff is medium on these soils. The erosion hazard from water is moderate. The surface layer is friable. Tilth is good, and the surface layer is easy to till.

This soil is well suited to row crops and hay. Capability unit IIe-1; woodland suitability group 1o1.

Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded (T76C2).—This moderately sloping soil is on convex side slopes of loess-covered benches adjacent to wide river bottoms. These benches are underlain by alluvium at a depth of 10 to 15 feet. Areas are 5 to 20 acres in size.

The surface layer of this soil is more eroded and is thinner than that in the profile described as representative for the Ladoga series. It is 4 to 7 inches thick and is light silty clay loam in places where erosion has removed much of it and plowing has mixed in the more clayey subsoil material. In many places the former lighter colored subsurface layer is

mixed with the surface layer. The surface layer is darker and thicker in some of the very narrow drainageways than it is in other areas.

Included with this soil in mapping are severely eroded spots and more extensive areas that are only slightly eroded. These are shown on the map by the symbol for an erosion spot. Also included are a few sandy areas of Chelsea soils. These are shown on the map by the symbol for a sand spot.

Runoff is medium on this soil, and cultivated areas are readily eroded by runoff water. This soil is used mainly for row crops. The plow layer is friable. The content of organic matter and the amount of clayey subsoil material that is mixed into the plow layer affects the tilth.

If this soil is properly managed, it is moderately well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Lamoni Series

The Lamoni series consists of deep, somewhat poorly drained soils on uplands. Lamoni soils are in narrow areas on short, convex side slopes. They formed in a thin layer of loess and a weathered, clayey glacial till called the "Yarmouth-Sangamon paleosol." The upper boundary of these soils is at the loess-till contact line. Slopes are 5 to 14 percent. The native vegetation was grass.

In a representative profile the surface layer is black silty clay loam 10 inches thick. The subsoil extends to a depth of 45 inches. The upper part is dark grayish-brown silty clay loam. It changes with depth to dark grayish-brown silty clay that has strong-brown mottles. The lower part of the subsoil is light-gray clay loam. It has grayish or brownish mottles. The middle is light brownish-gray to light-gray light clay that has strong-brown mottles. The underlying material is mottled, strong-brown and light-gray clay loam that has soft, dark-colored oxides.

Available water capacity is high in these soils. Permeability is slow to very slow and because of this the more permeable soils above are seepy during wet periods. The surface layer is generally medium acid unless it has been limed and is moderate to high in content of organic matter. The subsoil is low in available phosphorus and low to medium in available potassium.

Lamoni soils are poorly suited to row crops. They are well suited to pasture.

Representative profile of Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded, in a grassy pasture 360 feet north and 192 feet west of the SE. corner of the SW¼ NE¼ sec. 12, T. 77 N., R. 17 W.:

A1—0 to 10 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when crushed and grayish brown (10YR 5/2) when dry; moderate, medium and fine, granular structure; friable; common roots; slightly acid; clear, smooth boundary.

B1t—10 to 14 inches, dark grayish-brown (10YR 4/2) light silty clay loam; moderate, very fine, subangular blocky structure; firm; thin, discontinuous clay films; common roots; medium acid; clear, smooth boundary.

B21t—14 to 20 inches, dark grayish-brown (10YR 4/2) light silty clay; few, fine, distinct mottles of strong brown (7.5YR 5/6); very dark grayish-brown (10YR 3/2) coatings on ped faces; moderate, fine, subangular blocky structure; firm; thin, continuous clay films; common roots; medium acid; gradual, smooth boundary.

IIB22t—20 to 28 inches, light brownish-gray (2.5Y 6/2) light clay; common, fine, distinct mottles of brown (10YR 4/3), strong brown (7.5YR 5/6), and light gray (5Y 6/1); moderate, fine, subangular blocky structure; very firm; thin, discontinuous clay films; few roots; common coarse sand grains; strongly acid; gradual, smooth boundary.

IIB23t—28 to 32 inches, light-gray (5Y 6/1) light clay; common, fine, prominent mottles of yellowish brown (10YR 5/6); very firm; thin, discontinuous clay films; few roots; many, coarse sand grains and common pebbles; strongly acid; gradual, smooth boundary.

IIB3t—32 to 45 inches, light-gray (5Y 7/1) heavy clay loam; common, coarse, prominent mottles of strong brown (7.5YR 5/6); weak, medium, subangular blocky structure; firm; thin, discontinuous clay films; gray (N 5/0) clay balls at a depth of 44 inches; many coarse sand grains and common pebbles; medium acid; gradual, smooth boundary.

IIc—45 to 62 inches, mottled, strong-brown (7.5YR 5/8) and light-gray (5Y 6/1) clay loam; massive; firm; dark-gray (10YR 4/1) clay flows in old root channels; common, coarse, soft dark oxides; medium acid.

The A horizon, where it is not eroded, ranges from 10 to 13 inches in thickness. It is black (10YR 2/1) in uncultivated areas and very dark grayish brown (10YR 3/2) in cultivated areas. The A horizon is light silty clay loam to clay loam. The upper part of the B horizon has hues of 10YR to 2.5Y. Mottles in this part have hues of 7.5Y and 2.5Y. The B2t horizon is typically light clay but ranges from silty clay to clay or clay loam.

Lamoni soils are associated with Armstrong, Clarinda, and Clearfield soils. They are lower in content of clay and have more sand in the lower part of the B horizon than Clarinda soils. The B2 horizon in Lamoni soils is higher in content of clay than the B2 horizon in Clearfield soils. Unlike Armstrong soils, Lamoni soils lack an A2 horizon and do not have reddish mottles in the B horizon.

Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded (822C2).—This soil is on convex upland side slopes near the upper ends of drainageways just below the loess-till contact line, or seep line. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 5 to 20 acres in size.

Included with this soil in mapping are small areas of Clarinda and Clearfield soils near the upper boundary of the mapping unit. Also included are small areas of Gara and Shelby soils near the lower boundary.

Runoff is medium on this soil. The hazard of water erosion is moderate. This soil is often wet in spring. It is difficult to cultivate because it is sticky when wet and hard when dry.

This Lamoni soil is commonly used for row crops, because it is in rather small areas that are cultivated along with adjacent more productive soils. It is poorly suited to corn and soybeans. It is well suited to hay, pasture, or meadow. Capability unit IIIe-4; woodland suitability group 5w1.

Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded (822D2).—This sloping soil is on convex upland side slopes near the upper end of drainageways. It is below the loess-till contact line and runs on the contour along hillsides. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 10 to 20 acres in size.

This soil has the profile described as representative for the Lamoni series, but in some places the surface layer is thinner.

Included with this soil in mapping are small areas of severely eroded Lamoni soils. These are shown on the soil map by the symbol for severely eroded spots. Also included are areas of Clarinda and Armstrong soils near the upper boundary of the mapping unit and small areas of Gara and Shelby soils near the lower boundary.

This soil is generally in small areas that are adjacent to more productive soils and is commonly used for row crops. It is poorly suited to corn and soybeans. It is well suited to hay, meadow, or pasture. Capability unit IVe-2; woodland suitability group 5w1.

Landes Series

The Landes series consists of deep, well-drained soils that formed in sandy alluvium. These soils are on the nearly level, broad flood plains of the larger streams in the county. Slopes are 0 to 2 percent. The native vegetation was grass.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam 11 inches thick. The next layer is mixed dark grayish-brown and very dark grayish-brown fine sandy loam that extends to a depth of 22 inches. The underlying material is alluvial sediment that consists of several layers of very dark grayish-brown to grayish-brown very fine sandy loam.

Available water capacity is low in these soils. Permeability is moderately rapid to rapid. The surface layer is moderate in content of organic matter. The subsoil is very low in available phosphorus and potassium.

These soils are commonly subject to overflow in spring unless they are protected. The soil-blowing hazard is generally at its peak late in winter and early in spring.

Under proper management, these soils are moderately well suited to row crops and well suited to hay.

Representative profile of Landes fine sandy loam, 0 to 2 percent slopes, in a cultivated area 140 feet east and 360 feet south of the NW. corner of the SE¼SE¼ sec. 19, T. 75 N., R. 17 W.:

A1—0 to 11 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, fine, granular structure; very friable; neutral; clear, smooth boundary.

AC—11 to 22 inches, weakly stratified, about 70 percent dark grayish-brown (10YR 4/2) and 30 percent very dark grayish-brown (10YR 3/2) fine sandy loam; weak, fine, granular structure; very friable; neutral; gradual, smooth boundary.

C1—22 to 30 inches, very dark grayish-brown (10YR 3/2) very fine sandy loam; weak, fine and medium, subangular blocky structure that parts to weak, fine, granular; very friable; fine sand grains on some ped faces; neutral; gradual, smooth boundary.

C2—30 to 42 inches, dark grayish-brown (10YR 4/2) very fine sandy loam; common, medium, faint mottles of grayish brown (10YR 5/2) below a depth of 36 inches; weak, fine, granular structure; neutral; gradual, smooth boundary.

C3—42 to 60 inches, weakly stratified dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) very fine sandy loam and loamy fine sand; weak, fine, granular structure; neutral.

The A horizon is fine sandy loam or sandy loam that ranges from 10 to 16 inches in thickness. It is typically very dark grayish brown (10YR 3/2) but in places is very dark brown (10YR 2/2). Depth to the C horizon ranges from 12 to 22 inches. To a depth of about 40 inches these Landes soils are typically fine sandy loam or very fine sandy loam, but they range to sandy loam or loamy fine sand in places.

Landes soils are associated with Flagler, Nodaway, and Sparta soils. They have less sand and gravel in the C horizon than Flagler soils, are more sandy throughout their profile than Nodaway soils, and are not as sandy in the upper 40 inches as Sparta soils. Sparta soils are on adjoining uplands.

Landes soils in Mahaska County are outside the range of the series in that they have neutral reaction and lack free carbonates within depths of 40 inches, but these differences do not significantly affect their use and management.

Landes fine sandy loam, 0 to 2 percent slopes (208).—This soil is on smooth to gently undulating flood plains along the larger streams in the county (fig. 11). Areas of this soil are somewhat parallel to stream channels. The areas are irregular in shape and generally 20 to 50 acres in size, but in places on the Des Moines River bottom they are 100 acres or more. This soil has the profile described as representative for the Landes series.

Figure 11.—**Typical area of Landes fine sandy loam (*foreground*) and Boone fine sandy loam (*upland in background*).**

Included with this soil in mapping are small areas of Nodaway, Amana, and Flagler soils.

Runoff is slow on this soil. Water enters this soil rapidly, but the soil tends to be droughty and has a hazard of soil blowing. The surface layer is very friable and easy to till. It is subject to flooding.

This soil is moderately well suited to corn and soybeans. It is well suited to hay and to use as pasture or meadow. Capability unit IIw-4; woodland suitability group 5w2.

Lindley Series

The Lindley series consists of deep, well drained and moderately well drained soils on uplands. They formed in clay loam glacial till. Lindley soils are generally on the lower part of side slopes of strongly dissected upland divides. Slopes are 9 to 25 percent. The native vegetation was trees.

In a representative profile the surface layer is very dark gray loam 5 inches thick. The subsurface layer is dark grayish-brown loam 3 inches thick. The subsoil extends to a depth of 41 inches. The upper 4 inches is brown light clay loam that has common gray silt coatings on the faces of peds. Yellowish-brown medium clay loam is below that depth. The substratum, at a depth of about 41 inches, is mottled, yellowish-brown and pale-brown medium clay loam that is moderately alkaline.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is low to very low in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium. These soils erode readily if cultivated or overgrazed.

The less sloping Lindley soils are suited to limited use for crops. Many cleared areas of these soils have been cultivated in the past, but have been allowed to revert to permanent vegetation because they were not productive. In general these soils are better suited to pasture or trees than to other uses. They provide suitable sites for farm ponds that provide

water for livestock in most places. Wildlife habitat can be established in areas around the ponds.

Representative profile of Lindley loam, 18 to 25 percent slopes, moderately eroded, in a grassy pasture 45 feet north and 220 feet east of the fence corner that is approximately at the SW. corner of the NW¼NE¼ sec. 19, T. 77 N., R. 14 W.:

A1—0 to 5 inches, very dark gray (10YR 3/1) loam, light brownish gray (10YR 6/2) when dry; weak, very fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—5 to 8 inches, dark grayish-brown (10YR 4/2) loam, dark-gray (10YR 4/1) coatings on ped faces, light brownish gray (10YR 6/2) when dry; weak, coarse, platy structure that parts to moderate, fine and very fine, subangular blocky; friable; common pebbles; medium acid; abrupt, smooth boundary.

B1—8 to 12 inches, brown (10YR 5/3) light clay loam, very pale brown (10YR 7/3) when dry; moderate, fine and very fine, subangular blocky structure; friable; common gray silt coatings on ped faces; medium acid; clear, smooth boundary.

B21t—12 to 22 inches, yellowish-brown (10YR 5/6) medium clay loam, yellowish-brown (10YR 5/4) coatings on ped faces; weak, medium, subangular blocky structure that parts to moderate, fine and very fine, angular and subangular blocky; firm; thin, discontinuous clay films; strongly acid; diffused, smooth boundary.

B22t—22 to 35 inches, yellowish-brown (10YR 5/6) medium clay loam; moderate, medium, subangular blocky structure; firm; thin, discontinuous clay films of dark grayish brown (10YR 4/2); common pebbles and coarse sand grains; strongly acid; gradual, smooth boundary.

B3t—35 to 41 inches, yellowish-brown (10YR 5/4) medium clay loam, light yellowish-brown (10YR 6/4) coatings on ped faces; weak, medium, prismatic structure that parts to weak, medium, subangular blocky; distinct mottles of light gray (5Y 6/1); firm; thin, discontinuous clay films on vertical ped faces; few small lime concretions; some oxide stains on ped faces; common pebbles; moderately alkaline; clear, smooth boundary.

C—41 to 61 inches, coarsely mottled yellowish-brown (10YR 5/6) and pale-brown (10YR 6/3) medium clay loam; massive with some vertical cleavage; firm; moderately alkaline.

The A1 horizon is very dark gray (10YR 3/1) or dark grayish-brown (10YR 4/2) loam or silt loam unless it is eroded. The A2 horizon is 10YR in hue, 4 to 6 in value, and 2 to 4 in chroma. The B2t horizon has a hue of 10YR or 7.5YR, a value of 4 or 5, and chromas of 4 to 6. The maximum content of clay in the B2t horizon ranges from 32 to 38 percent, but average content of clay in the upper 20 inches of the B horizon is less than 35 percent. Mottles in the lower part of the B horizon and the C horizon range from light gray (10YR 6/1) to strong brown (7.5YR 5/6). The B2t horizon ranges from very strongly acid to strongly acid in the most acid part.

Lindley soils are associated with Keswick and Gara soils and formed in material similar to that of the parent material of Gara soils. They differ from Gara soils in having a thinner or lighter colored A1 horizon when plowed and generally have a more pronounced A2 horizon than Gara soils. The Lindley soils lack the reddish, clayey B horizon of the Keswick soils.

Lindley loam, 9 to 14 percent slopes, moderately eroded (65D2).—This soil is on convex upland side slopes and on some narrow ridgetops in the strongly dissected areas of the county. It is generally below Keswick or Clinton soils and above more strongly sloping Lindley soils. Areas are narrow and irregular in shape and are generally 5 to 15 acres in size.

This soil has a profile similar to that described as representative for the Lindley series. The surface layer of this soils is dark grayish-brown or brown light clay loam in some places. In the small natural waterways that extend up into the side slopes, the surface layer is darker and thicker than it is in other areas.

Included with this soil in mapping are areas where the surface layer has been severely eroded, leaving the yellowish-brown clay loam subsoil exposed. These areas are shown on the map by the symbol for a severely eroded spot. Also included are small areas of Keswick soil, which are shown on the map by the special symbol for a spot of reddish clay. In the southwestern part of the county, especially, are small areas of soil that formed in shale. These, too, are shown on the soil map by a special symbol.

Runoff is rapid on this soil. The hazard of water erosion is severe. The surface layer is low in content of organic matter, but is friable.

This Lindley soil is poorly suited to corn or soybeans. It is well suited to hay, pasture, or trees. Capability unit IVe-3; woodland suitability group 2o1.

Lindley loam, 14 to 18 percent slopes, moderately eroded (65E2).—This soil is on convex upland side slopes in the strongly dissected areas of the county. It commonly extends in narrow, irregular bands that form the sides of valleys. This soil is generally below strongly sloping Clinton soils. In places, near the ends of ridges, it is downslope from strongly sloping Keswick soils. The areas are elongated. irregular in shape, and 5 to more than 30 acres in size.

This soil has a profile similar to that described as representative for the Lindley series, but the surface layer is thinner and often contains more clay. The surface layer of this soil is brown or dark grayish-brown heavy loam or light clay loam in most places. In the small natural waterways that extend up into the side slopes in these soils, the color of the surface layer is darker and the loamy material is deeper.

Included with this soil in mapping are a few areas where the surface layer has been removed by erosion and the yellowish-brown subsoil is exposed. These areas are indicated on the map by the symbol for a severely eroded spot. In the southwestern part of the county and in places elsewhere are small areas of shallow soil that developed in shale. These are shown by a special symbol. Small areas of Keswick soil are shown on the soil map by the special symbol for a spot of reddish clay.

Much of this soil has at one time been cultivated but has been allowed to revert to pasture because of the low natural fertility, the steepness of slopes, and the severe hazard of erosion.

This soil is suited to pasture, trees, and wildlife habitat. It is suitable for pond sites. This soil is poorly suited to corn and soybeans. Capability unit VIe-1; woodland suitability group 2o1.

Lindley loam, 18 to 25 percent slopes, moderately eroded (65F2).—This soil is on the lower part of convex uplands. It generally extends down long hillsides to the soils of the foot slopes or first bottoms. Areas are long and narrow, irregular in shape, and 10 to 40 acres in size.

This soil has the profile described as representative for the Lindley series, but in some places carbonates in the substratum are at a somewhat shallower depth. In the small natural waterways that extend up into the side slopes in the soil, the color of the surface layer is darker than it is in other areas, and the loamy material is thicker.

Included with this soil in mapping are a few areas where the surface layer has been removed by erosion and the yellowish-brown clay loam subsoil is exposed. These areas are indicated on the soil map by the symbol for a severely eroded spot. In the southwestern part of the county and in places elsewhere are areas of a shallow soil that formed in weathered shale, sandstone, or limestone. These are indicated on the soil map by appropriate spot symbols. In a few places

small areas of Keswick soils are on the points of ridges. These are shown on the soil map by the special symbol for a spot of reddish clay. A few areas of very steep Lindley soil, 25 to 40 percent slopes, are also included.

Runoff is rapid on this soil. The hazard of erosion is severe.

Much of this soil is presently in permanent pasture. The more sloping areas are generally in trees. This soil is suited to limited pasture, woods, and wildlife habitat. This soil has suitable sites for ponds. It is not suitable for crops. Capability unit VIIe-1; woodland suitability group 3r1.

Lindley-Keswick complex, 9 to 14 percent slopes, moderately eroded (424D2).—This complex is on hillsides in uplands below the loess-till contact line. Slopes are convex. Areas are rather long and narrow and extend horizontally around hillsides and into drainageways. The Lindley soil is in the lower part of the hillsides and makes up about 70 to 85 percent of the complex. The Keswick soil is upslope from the Lindley soil and makes up 15 to 30 percent of the complex. The areas are generally 10 to 30 acres in size.

Included with these soils in mapping are less eroded Lindley and Keswick soils and areas of Armstrong and Gara soils. In places small severely eroded areas of these soils are included in this complex. These are shown on the soil map by the symbol for a severely eroded spot. Also included are small areas of Clarinda soil in places along the upper boundary of the mapping unit near the heads of drainageways.

Runoff is medium or high on soils of this complex. The hazard of erosion is moderate. In places a seep line develops in the more permeable loess soils just above the Keswick soil during wet periods. The surface layer of eroded Keswick soil often becomes sticky when wet and hard when dry.

This complex is rather poorly suited to corn and soybeans. It is better suited to hay or pasture. Capability unit IVe-3; woodland suitability group 2o1.

Lindley-Keswick complex, 14 to 18 percent slopes, moderately eroded (424E2).—This complex is on hillsides in uplands below the loess-till contact line. It is in long, narrow areas that extend horizontally around hillsides and into drainageways. Slopes are convex. The Lindley soil is on the lower part of the hillsides and makes up about 70 to 85 percent of the complex. The Keswick soil is upslope from the Lindley soil and makes up 15 to 30 percent of the complex. The areas are generally 20 to 60 acres in size.

Included with these soils in mapping are less eroded Lindley and Keswick soils and areas of Armstrong and Gara soils. In some places severely eroded areas of these soils are included in this complex. These are shown on the map by a special symbol. Small areas of a soil similar to Armstrong soil that is underlain by glacial till or shale are along the lower boundary of this mapping unit in places.

Runoff is high on soils of this complex. The hazard of erosion is severe. In places a seep line develops in the more permeable soil just above the Keswick soil during wet periods. The surface layer of eroded Keswick soil often becomes sticky when wet and hard when dry.

This complex is not suited to corn and soybeans. It is suited to pasture or trees. Capability unit VIe-1; woodland suitability group 2o1.

Mahaska Series

The Mahaska series consists of deep, somewhat poorly drained soil that formed in loess. These soils are on smooth, nearly level or gently sloping uplands and on high stream benches. Slopes are 0 to 5 percent. The native vegetation was grass.

In a representative profile the surface layer is black silty clay loam 14 inches thick. The subsoil is silty clay loam that extends to a depth of 55 inches. It is very dark grayish brown or dark grayish brown in the upper part, and this part has a few mottles of yellowish brown. The middle is grayish brown and has mottles of olive yellow and yellowish brown. The lower part of the subsoil is light olive brown and has mottles of yellowish brown. The subsoil has clay films on ped faces in all parts and clay flows in old root channels below a depth of 40 inches. The underlying material is light-gray light silty clay loam that has mottles of strong brown and contains a few oxides.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is generally slightly acid unless it has been limed and is high in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium. Mahaska soils need drainage to make timely farming operations possible.

Mahaska soils are well suited to and are used intensively for row crops where drainage is adequate.

Representative profile of Mahaska silty clay loam, 0 to 2 percent slopes, in a cultivated area 264 feet west and 528 feet south of the NE. corner of SW¼SE¼ sec. 25, T. 74. N., R. 15 W.:

Ap—0 to 7 inches, black (N 2/0) medium silty clay loam; moderate, very fine and fine, granular structure; friable; few roots; neutral; abrupt, smooth boundary.

A1—7 to 14 inches, black (N 2/0) medium silty clay loam; moderate, medium, subangular blocky structure; friable; few roots; slightly acid; gradual, smooth boundary.

B1—14 to 20 inches, very dark grayish-brown (10YR 3/2) heavy silty clay loam; moderate, medium, subangular blocky structure that parts to moderate, very fine, subangular blocky; firm; few roots; slightly acid; clear, smooth boundary.

B21t—20 to 24 inches, dark grayish-brown (2.5Y 4/2) heavy silty clay loam; few, fine, distinct mottles of yellowish brown (10YR 5/6); moderate, medium, prismatic structure that parts to moderate, medium and fine, subangular blocky; firm; thick, continuous, very dark gray (10YR 3/1) clay films; medium acid; clear, smooth boundary.

B22tg—24 to 33 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; common, fine, distinct mottles of olive yellow (2.5Y 6/6); moderate, medium, prismatic structure that parts to moderate, fine, subangular blocky; firm; thick, continuous clay films; slightly acid; gradual, smooth boundary.

B23tg—33 to 42 inches, grayish-brown (2.5Y 5/2) silty clay loam; common distinct mottles of yellowish brown (10YR 5/6); weak, fine, prismatic structure that parts to weak, medium, subangular blocky; firm; thick, continuous clay films; common clay flows in root channels; neutral; gradual, smooth boundary.

B3tg—42 to 55 inches, light olive-brown (2.5Y 6/2) light silty clay loam; many distinct mottles of yellowish brown (10YR 5/6); weak, coarse, subangular blocky structure; firm; common dark-gray (10YR 4/1) clay flows in root channels; neutral; gradual, smooth boundary.

Cg—55 to 96 inches, light-gray (5Y 6/1) light silty clay loam; common, coarse to medium, prominent mottles of strong brown (7.5YR 5/6); massive; friable; few medium oxides; neutral.

The A1 horizon is light or medium silty clay loam that ranges from 11 to 18 inches in thickness. It is black (N 2/0 or 10YR 2/1). The B1 horizon has hues of 2.5Y to 10YR, a value of 3 or 4, and a chroma of 1 or 2. The B2t horizon is medium or heavy silty clay loam. It has mottles that range in hue from 2.5Y to 10YR, in value from 4 to 6, and in chroma from 2 to 6. Clay films range from thin and discontinuous to thick and continuous in this horizon. Soft oxides of iron and manganese are present in places. The B3t horizon

is medium or light silty clay loam, and mottles have hues that range from 2.5Y to 5Y and to 10YR, have a value of 5 or 6, and have chromas of 2 to 8. In places are soft oxides of iron and manganese. The underlying material ranges from light silty clay loam to silt loam. It has hues of 2.5Y to 5Y, a value of 5 or 6, and chromas of 1 to 6.

Mahaska soils are associated with Givin, Otley, and Taintor soils and formed in material similar to that of the parent material of Grundy soils. They are browner in the upper part of the B2t horizon than Taintor soils. Mahaska soils have a thicker dark A1 horizon than Givin soils and lack the A2 horizon of Givin soils. Mahaska soils are not as brown in the upper part of the B2t horizon as Otley soils. They have less clay in the B2t horizon than Grundy soils.

Mahaska silty clay loam, 0 to 2 percent slopes (280).—This soil is on smooth, broad upland divides. Areas of this soil are generally long and narrow, have irregular boundaries, and are 40 to more than 80 acres in size. Some areas are more than a mile long. This soil has the profile described as representative for the Mahaska series (fig. 12).

Included with this soil in mapping are small areas of Taintor, Grundy, Givin, and Otley soils and, in places, small areas of Sperry and Rubio soils. These included soils make up less than 20 percent of a mapping unit.

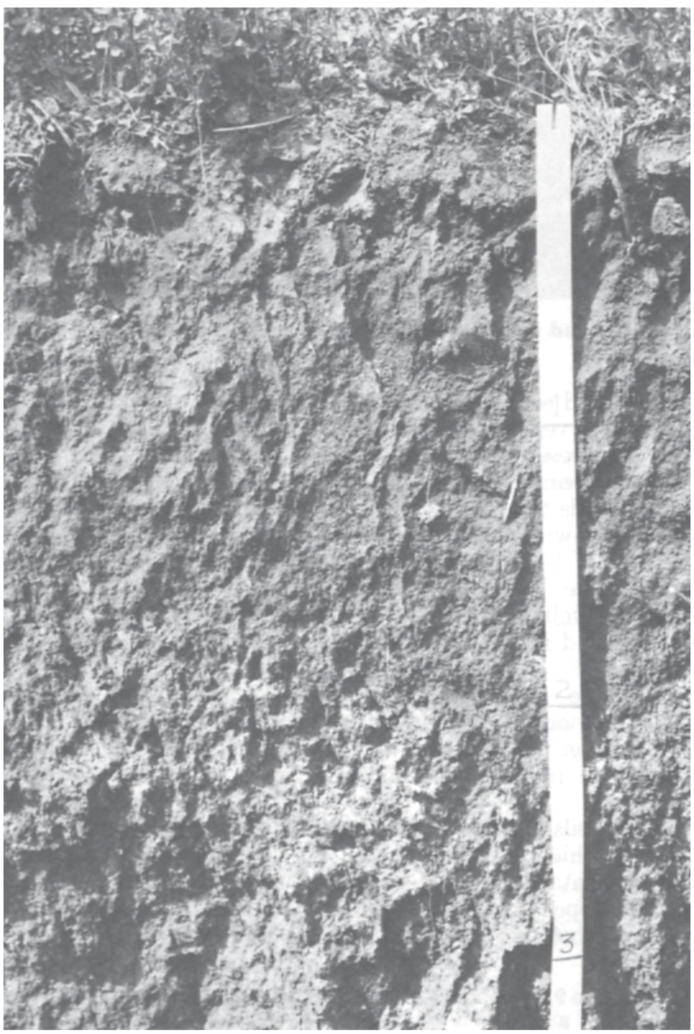


Figure 12.—**Representative profile of Mahaska silty clay loam.**

Runoff is slow on this soil. Drainage is needed for timely farming operations. The surface layer remains friable if this soil is not worked when it is too wet. If it is worked when too wet, the soil becomes firm in places, and compaction is a concern. Under proper moisture conditions tilth is good, and the soil is moderately easy to till.

This soil is used intensively for and is well suited to corn, soybeans, and hay. Capability unit I-1; woodland suitability group 3w1.

Mahaska silty clay loam, 2 to 5 percent slopes (280B).—This soil is on uplands along the edges of broad divides and near the heads of drainageways. It has smooth, convex slopes. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 20 to 60 acres in size.

This soil has a profile similar to that described as representative for the series, but the dark surface layer is thinner than the one in the representative profile, and mottles are at a greater depth in the upper part of the subsoil.

Included with this soil in mapping are small areas of Otley and Givin soils. These included areas make up less than 20 percent of the mapping unit.

Runoff is moderately slow on this soil. Drainage is needed in some places for timely farming operations. The surface layer is generally friable and moderately easy to till. Tilth is generally good.

This soil is used intensively for growing corn (fig. 13), soybeans, and hay. It is well suited to those uses. Capability unit IIe-1; woodland suitability group 3w1.

Mahaska silty clay loam, benches, 1 to 3 percent slopes (T280).—This soil is on smooth, high benches in the valleys of the larger streams in the county. Areas of this soil are generally long and narrow, have irregular boundaries, and are 5 to more than 30 acres in size.

This soil has a profile similar to that described as representative for the Mahaska series, but the surface layer is more silty and less clayey. The underlying material, at a depth of 7 to 14 feet, is stratified alluvium. Included with this soil in mapping are small areas of Sperry and Rubio soils that are 1/10 acre to 2 acres in size.

Runoff is slow on this soil. Drainage is needed for timely farming operations. The surface layer is friable if this soil is not worked when it is too wet. If it is worked when too wet, the soil becomes firm in places, and compaction is a concern. Under proper moisture conditions this soil is moderately easy to till and tilth is good.

This soil is used intensively for and is well suited to corn, soybeans, and hay. Capability unit I-1; woodland suitability group 3w1.

Marsh

Marsh (354) is in slight depressions on bottom lands of the Des Moines and Skunk Rivers. The water table is at or near the surface of Marsh most of the year (fig. 14). A small area of Marsh is north of the water-treatment plant, about 3 miles north of Oskaloosa. This area extends east and west of U.S. Highway 63. The vegetation is sedges, cattails, and willows. Areas of Marsh are irregular in shape and range from 3 to 30 acres in size. Areas that are smaller than 3 acres are shown on the soil map by the special symbol for small areas of Marsh.

Black or very dark gray silt loam extends to a depth of several inches in Marsh. Below this is gray silty clay loam.

Figure 13.—**Stripcropping on gently sloping Mahaska silty clay loam and moderately sloping Otley silty clay loam.**

The surface of Marsh is frequently ponded by overflow water. Drainage development is difficult because of lack of slope towards the stream channel.

Marsh is not suited to crops or hay. It has little or no value as pasture. It is well suited to wildlife habitat. Capability unit VIIw-1; woodland suitability group not assigned.

Mine Pits and Dumps

Mine pits and dumps (**502**) consists of areas where coal has been mined. These areas have open, trench-type pits that are as much as 40 feet deep or deeper. The dumps consist of piles of extremely acid, carbonaceous spoil material 15 to 30 feet high.

The pits and dumps remain entirely devoid or nearly devoid of vegetation. Water accumulates in most of the abandoned pits, but it is generally too acid for fish.

The idle land between or adjacent to the pits and dumps eventually produces a growth of annual weeds, grasses, and trees after the mining has been completed.

Because the soil material varies, this mapping unit has not been placed in a capability unit or a woodland suitability group.

Nevin Series

The Nevin series consists of deep, somewhat poorly drained soils that formed in silty alluvium. These soils are on low benches and second bottoms. Slopes are less than 2 percent. The native vegetation was grass.

In a representative profile the surface layer is black light silty clay loam 26 inches thick. The subsoil is silty clay loam that extends to a depth of 57 inches. The upper part is dark grayish brown and has mottles of dark yellowish brown, and the middle is grayish brown and has mottles of yellowish brown. The lower part is mottled and is light brownish gray and yellowish brown. The underlying material is also mottled and is brown, yellowish-brown, and light-gray silty clay loam.

Available water capacity is high in these soils. Permeability is moderate or moderately slow. Runoff is slow. The surface layer is high in content of organic matter. The subsoil is medium in available phosphorus and high in available potassium.

These soils are used intensively for row crops and are well suited to this use.

Representative profile of Nevin silty clay loam, 0 to 2 percent slopes, in a cultivated area 700 feet east and 265 feet north of the SW. corner of NW¼SW¼ sec. 21, T. 76 N., R. 16 W.:

Ap—0 to 9 inches, black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) when crushed and dark gray (10YR 4/1) when dry; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A12—9 to 16 inches, black (10YR 2/1) light silty clay loam;

Figure 14.—**An area of Marsh in the valley of the Des Moines River. (Muskrat home is in center.)**

moderate, fine, granular structure; friable; neutral; clear, smooth boundary.

A3—16 to 26 inches, black (10YR 2/1) and very dark grayish-brown (10YR 3/2) silty clay loam; moderate, medium, granular structure; friable; slightly acid; clear, smooth boundary.

B1—26 to 36 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark gray (10YR 3/1) coatings on ped faces; common, fine, faint mottles of yellowish brown (10YR 5/6); moderate, fine and medium, subangular blocky structure; friable; thin, discontinuous clay films; slightly acid; clear, smooth boundary.

B2t—36 to 48 inches, grayish-brown (10YR 5/2) silty clay loam; dark grayish-brown (10YR 4/2) coatings on ped faces; many, medium, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to moderate, fine and medium, subangular blocky; friable; thin, discontinuous clay films; neutral; gradual, smooth boundary.

B3t—48 to 57 inches, mottled, light brownish-gray (10YR 6/2) and yellowish-brown (10YR 5/4 and 5/6) silty clay loam; weak, medium, subangular blocky structure; friable; thin, discontinuous clay films; neutral; gradual, smooth boundary.

C—57 to 72 inches, mottled, brown (10YR 4/3), yellowish-brown (10YR 5/4), and light-gray (2.5Y 7/2) silty clay loam; massive; friable; neutral.

The A horizon ranges from 22 to 30 inches in thickness. It is mainly light silty clay loam but is silt loam in places. The B2t horizon ranges from dark gray (10YR 4/1) to dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2). The B horizon is silty clay loam that averages 32 to 36 percent clay. The B2t horizon has less range in content of clay, averaging about 34 percent. The C horizon has sandy or clayey sediment below a depth of 60 inches.

Nevin soils are associated with Ely, Judson, and Wiota soils and are similar to Mahaska soils, which are somewhat poorly drained. The upper part of the B horizon in Nevin soils is grayer than that of Wiota and Judson soils. Nevin soils have more clay in the B horizon than Ely soils and have less clay in the B horizon than Mahaska soils. They formed in alluvium, whereas Mahaska soils formed in loess.

Nevin silty clay loam, 0 to 2 percent slopes (88).—This soil is on smooth to slightly undulating low benches or second bottoms. It is generally in long, irregularly shaped areas 10 to 30 acres in size that are somewhat parallel to creeks and rivers. The profile of this soil is the one described as representative for the Nevin series.

Included with this soil in mapping are small areas of poorly drained Bremer, Colo, and Zook soils. These make up as much as 15 percent of the mapping unit.

Tile drainage is generally not needed on this soil, but it may be beneficial along drainageways in depressions.

This soil is used intensively for and is well suited to corn and soybeans. Capability unit I-1; woodland suitability group 3w1.

Nira Series

The Nira series consists of deep, moderately well drained soils that formed in grayish deoxidized loess on uplands. Slopes are short and convex and range from 2 to 9 percent. The native vegetation was grass.

In a representative profile the surface layer is very dark brown or very dark grayish-brown light silty clay loam 13 inches thick. The subsoil is silty clay loam that extends to a depth of 48 inches. It is mixed very dark grayish brown, brown, and grayish brown in the upper part; grayish brown with mottles of dark yellowish brown, yellowish brown, and strong brown in the middle; and mottled, light olive gray and strong brown in the lower part. The underlying material is light-gray heavy silt loam that has mottles of yellowish brown to a depth of 84 inches and dark-gray light silty clay loam below that depth.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is generally slightly acid unless it has been limed, and it is moderate in content of organic matter. The subsoil is very low in available phosphorus and potassium. The hazard of water erosion is moderate.

Under proper management these soils are well suited or moderately well suited to row crops and hay. They are generally farmed along with the adjoining soils.

Representative profile of Nira silty clay loam, 2 to 5 percent slopes, in a cultivated area 170 feet north and 1,200 feet east of the SW. corner of sec. 6, T. 76 N., R. 17 W.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) light silty clay loam, grayish brown (10YR 5/2) when dry; moderate, fine, subangular blocky structure; friable; common roots; neutral; clear, smooth boundary.

A3—7 to 13 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, very dark brown (10YR 2/2) coatings on ped faces, grayish brown (10YR 5/2) when dry; weak, fine, subangular blocky structure; friable; common roots; neutral; clear, smooth boundary.

B1—13 to 17 inches, mixed very dark grayish-brown (10YR 3/2) and brown (10YR 4/3) light silty clay loam, grayish brown (10YR 5/2) when dry; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B21t—17 to 22 inches, mixed brown (10YR 4/3) and grayish-brown (2.5Y 5/2) silty clay loam; dark-brown (10YR 3/3) coatings on ped faces, brown (10YR 5/3) when dry; moderate, fine, subangular blocky structure; friable; thin, discontinuous clay films; common roots; slightly acid; clear, smooth boundary.

B22t—22 to 33 inches, grayish-brown (2.5Y 5/2) silty clay loam; few, fine, distinct mottles of dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), and strong brown (7.5Y 5/8); weak, medium, prismatic structure that parts to weak, fine, subangular blocky; friable; thin, discontinuous clay films; common roots; neutral; clear, smooth bounary.

B31t—33 to 38 inches, mottled, grayish-brown (2.5Y 5/2) and

Figure 15.—**Contour stripcropping on Nira silty clay loam, 5 to 9 percent slopes.**

yellowish-brown (10YR 5/6) silty clay loam; some dark grayish-brown (2.5Y 4/2) coatings on ped faces; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; friable; thin, discontinuous clay films; few roots; neutral; clear, smooth boundary.

B32t—38 to 48 inches, mottled, light olive-gray (5Y 6/2) and strong-brown (7.5YR 5/6) light silty clay loam; weak, medium, subangular blocky structure; friable; few root channels with dark organic stains; neutral; clear, smooth boundary.

C1—48 to 84 inches, light-gray (5Y 7/1) heavy silt loam; few, medium, prominent mottles of yellowish brown (10YR 5/8); massive; friable; common tubular pores; mildly alkaline; clear, smooth boundary.

C2—84 to 120 inches, dark-gray (10YR 4/1) light silty clay loam; common, coarse mottles of strong brown (7.5YR 5/8); massive; friable; mildly alkaline.

The A horizon ranges from 10 to 15 inches in thickness. The uneroded A1 horizon is typically very dark brown (10YR 2/2) but ranges to very dark grayish brown (10YR 3/2) in eroded soils where the upper part of the B horizon is often mixed into the Ap horizon. Maximum content of clay in the B2t horizon is 35 percent but ranges to 32 percent. The depth to colors in which a chroma of 2 is predominant ranges from 20 to 30 inches. Depth to the C horizon ranges from 20 to 30 inches. The loess mantle from which Nira soils formed ranges from 4 to 8 feet thick. Below this depth is a buried, gray clayey soil that formed in glacial till.

Nira soils are associated with Clearfield, Otley, and Mahaska soils. They have a grayer B2 horizon above a depth of 30 inches than Otley soils. They have less clay in the B2 horizon than Otley or Mahaska soils. They are browner in the upper part of the B horizon than Mahaska and Clearfield soils.

Nira silty clay loam, 2 to 5 percent slopes (570B).—This soil is on uplands and has short, convex slopes. It is commonly at the heads of waterways and on side slopes between waterways and is just above the seep line, or loess-till contact line. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 10 to 30 acres in size. This soil has the profile described as representative for the Nira series.

Included with this soil in mapping are small areas of Otley and Mahaska soils.

Runoff is medium on this soil. In places wetness is a slight concern at the heads of drainageways. The hazard of water erosion is slight. The surface layer is friable and easy to till. Tilth is good.

This soil is well suited to and is used intensively for corn, soybeans, and hay. Capability unit IIe-1; woodland suitability group 1o1.

Nira silty clay loam, 5 to 9 percent slopes (570C).—This soil is on uplands. It has short, convex slopes (fig. 15). Areas are commonly at the heads of waterways and on moderate side slopes between waterways just above the seep line, or loess-till contact line. The areas are generally rather long and narrow, have irregular boundaries, and are 20 to 40 acres or more in size.

This soil has a profile similar to that described as representative for the Nira series, but the thickness of the surface layer and subsoil and the depth to the maximum clay in the subsoil are slightly less.

Included with this soil in mapping are small areas of Otley, Ladoga, and Clearfield soils.

Runoff is medium on this soil. The hazard of water erosion is moderate. The surface layer is friable and easy to till. Tilth is good.

Under proper management, this soil is moderately suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Nira silty clay loam, 5 to 9 percent slopes, moderately eroded (570C2).—This soil has short, convex slopes. It is on uplands at the heads of waterways and on moderate side slopes between waterways just above the seep line, or loess-till contact line. The areas are generally rather long and narrow, have irregular boundaries, and are 20 to 40 acres in size.

This soil has a profile similar to that described as representative for the Nira series, but differs in that the surface layer is 3 to 7 inches thick, is lighter in color, and is lower in content of organic matter. Also, the depth to material that has the maximum content of clay is less in this soil and so are the depths to mottles and to the underlying material.

Included with this soil in mapping are small areas of severely eroded Nira soil on side slopes and nose slopes. Also included are small areas of Otley, Ladoga, Clearfield, and Clarinda soils.

Runoff is medium on this soil. The hazard of water erosion is moderate. The plow layer is friable, but the tilth depends somewhat upon content of organic matter and the amount of clay from the subsoil that has been mixed into the plow layer.

Under proper management this soil is moderately well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Nodaway Series

The Nodaway series consists of deep, stratified, moderately well drained soils on first bottoms. Slopes are less than 2 percent. These soils are generally adjacent to the stream channel, but they may be some distance from it in areas where the channel has been straightened. Nodaway soils formed in silty alluvium that was low in content of sand. The native vegetation was grasses and trees.

In a representative profile the surface layer is black heavy silt loam about 2 inches thick, below this is stratified dark grayish-brown and black light silty clay loam and silt loam to a depth of about 46 inches. Below this depth it is stratified silt loam and silty clay loam.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is low to moderate in content of organic matter. The subsoil is medium in available phosphorus and potassium. The water table is generally below a depth of 40 inches. If the soils are unprotected, they are subject to flooding. Areas that are protected from flooding are well suited to row crops. Other areas are used for pasture or trees.

Representative profile of Nodaway silt loam, 0 to 2 percent slopes, in a grassy and wooded area, about 300 feet west and 150 feet north of the SE. corner of the NW¼SW¼ sec. 25, T. 76 N., R. 16 W.:

A1—0 to 2 inches, black (10YR 2/1) heavy silt loam, dark gray (10YR 4/1) when dry; moderate, medium and fine, granular structure; friable; neutral; abrupt, smooth boundary.

C1—2 to 46 inches, stratified dark grayish-brown (10YR 4/2) coarse silt loam and black (10YR 2/1) light silty clay loam; light-colored strata of dark grayish brown (10YR 4/2) at a depth of 2 to 12 inches; total thickness of light-colored strata 29 inches and dark-colored strata 15 inches; many, medium, distinct strong-brown (7.5YR 5/6) mottles between depths of 5 and 11 inches and 37 and 46 inches; grayish brown (2.5Y 5/2) when crushed and dry; moderate, fine, platy structure; massive with weak horizontal cleavage; friable; common iron stains on ped faces at depths of 31 to 33 inches and 36 to 41 inches; neutral; clear, smooth boundary.

C2—46 to 76 inches, stratified black (10YR 2/1) silty clay loam and dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) silt loam; moderate, fine, subangular blocky structure; firm; strata 1 to 2 inches thick; neutral; abrupt boundary.

C3—76 to 96 inches, black (10YR 2/1) heavy silty clay loam; moderate, fine, subangular blocky structure; firm; lenses up to ½ inch thick of dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) silt loam; neutral.

The A1 horizon ranges from 2 to 6 inches in thickness when uncultivated and is grayish brown (10YR 5/2) to black (10YR 2/1). It is generally silt loam but ranges from fine sandy loam to light silty clay loam. The stratified alluvium below the A horizon is generally many feet thick. These strata are predominantly silt loam but in places are fine sand, sandy loam, silty clay loam, and silty clay. Colors are grayish brown (10YR 5/2) to black (10YR 2/1). Dark layers are less than 6 inches thick. The lighter colors predominate in the upper 40 inches. Reaction ranges from slightly acid to neutral.

Nodaway soils are associated with Amana, Kennebec, Ossian, and Spillville soils. They are lighter colored in the upper 36 inches than Kennebec soils, and unlike Kennebec soils are stratified and contain thin sand lenses. Nodaway soils are lighter colored and more stratified in the upper 24 inches than Spillville soils. They are more stratified and have a thinner A horizon than Ossian and Amana soils.

Nodaway silt loam, 0 to 2 percent slopes (220).—This soil is on smooth or slightly channeled first bottoms. Areas are 20 to 40 acres in size and are more or less parallel to the stream channel. They have irregular boundaries. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of Landes soils and Alluvial land. Also included are small areas less than 2 acres in size of a sandy overwash phase of Nodaway soil. These are shown on the soil map by the sand spot symbol.

Runoff is slow on this soil. Areas that are subject to overflow are generally protected by dikes where it is practical. Natural fertility varies with depth. Under proper management this soil can be very productive. Tilth is generally good.

This soil is well suited to corn and soybeans in bottom lands where it is protected from flooding. Areas that are not protected are generally used for pasture or trees. Capability unit IIw-5; woodland suitability group 5w2.

Nodaway silt loam, channeled, 0 to 2 percent slopes (C220).—This soil is on the first bottoms that are dissected by one or more meandering channels. Areas are along sharply curving stream channels and are flooded frequently. This mapping unit includes old stream channels, side gullies, and areas of associated Nodaway soils. The surface is somewhat uneven. Areas are generally less than 40 acres in size.

Included with this soil in mapping are areas where recent fine sand or coarse silt deposits are on the surface. Also included are small areas of Vesser, Amana, Ossian, Colo, and Zook soils and Alluvial land.

The meandering channels or side gullies cut this mapping unit into small areas. This dissecting seriously interferes with farming operations. Also, this soil has a more severe flooding hazard than the one described as representative for the series.

Production of row crops is impractical on this soil. Most areas are in trees and other woody plants. Generally, stream straightening and filling old channels are needed to make farming practical. Some areas are used for pasture. Capability unit Vw-1; woodland suitability group 5w2.

Nodaway-Alluvial land complex, 0 to 2 percent slopes (315).—Areas of this complex are present in many places alongside channels of larger streams. In most areas the soil and land are undulating and are subject to change by deposition. The undulations are somewhat irregular in size and shape but tend to aline generally in the direction of the stream channel. Nodaway silt loam and Alluvial land are about equally divided in the mapped areas. These areas are irregular in shape and are generally 20 to 60 or more acres in size.

The Nodaway soil in this complex has a profile similar to that described as representative of the Nodaway series. Alluvial land consists of unconsolidated, stratified, sandy and silty sediment. The profile of this land varies from place to place. Small areas of sand and gravel are indicated on the map by the symbol used for that purpose.

Runoff is slow on this complex. Areas are frequently flooded, and the water table is high during wet periods.

This complex is unsuited to crops unless it is protected from flooding, and even then it is only poorly suited. Areas that are protected from flooding are moderately suited to hay. Areas of this complex are generally used for pasture. Capability unit Vw-1; woodland suitability group 5w2.

Nodaway-Vesser silt loams, 2 to 5 percent slopes (13B).—This complex is on bottom land that includes a rather large stream channel (fig. 16). The valleys are commonly 300 to 600 feet wide and as much as one-half mile or more in length. Mapped areas are 30 to 60 or more acres in size. Nodaway silt loam is adjacent to the stream channel in the middle of the area, and it makes up about half of the area. Vesser silt loam is along the sides of the mapped area at slightly higher elevation than Nodaway silt loam. It makes up about 30 percent of the area. Included in mapping, and making up 20 percent of the mapped areas, are Colo, Kennebec, and Amana soils.

Runoff is slow on these soils. The water table is high during wet seasons except in areas that are protected and drained.

Figure 16.—**Nodaway-Vesser silt loams along a stream channel.**

Areas of this complex are subject to flooding during hard rains. The surface layer is friable, and tilth is good.

Under good management these soils are moderately well suited to corn and soybeans. They are well suited to hay and pasture. Capability unit IIw-3; woodland suitability group 5w2.

Olmitz Series

The Olmitz series consists of deep, moderately well drained to well drained soils that formed in loamy alluvium. The alluvium has been washed from adjacent soils that formed in glacial till and loess on uplands. These soils have straight or slightly concave slopes and are on foot slopes and alluvial fans. Slopes are 2 to 9 percent. The native vegetation was grass.

In a representative profile the surface layer is about 29 inches thick. It is black loam in the upper part and very dark grayish-brown light clay loam in the lower part. The subsoil is clay loam to a depth of 55 inches. It is brown in the upper part and yellowish brown and mottled in the middle. The lower part is mottled, yellowish-brown sandy clay loam. Soft oxides of iron and manganese, sand, gravel, and pebbles are in the lower part of the subsoil.

Available water capacity is high in these soils. Permeability is moderate or moderately slow. The surface layer is slightly acid unless it has been limed and is high in content of organic matter. The subsoil is very low in available phosphorus and potassium.

Runoff water from higher elevations deposits loamy sediment on the surface of these soils. Erosion is a hazard during hard rains, but it is not so great a hazard to young plants as is the accumulation of loamy material.

Olmitz soils can be cultivated intensively to row crops, but individual areas are generally so small that they are managed with adjacent soils.

Representative profile of Olmitz loam, 2 to 5 percent slopes, in a grassy area 480 feet west and 30 feet north of the SE. corner of sec. 34, T. 76 N., R 16 W.:

A1—0 to 18 inches, black (10YR 2/1) heavy loam, dark gray (10YR 4/1) when dry; moderate, fine and very fine, granular structure; very friable; common roots to a depth of 16 inches; slightly acid; gradual, smooth boundary.

A3—18 to 29 inches, very dark grayish-brown (10YR 3/2) light clay loam; very dark brown (10YR 2/2) coatings on ped faces; weak, medium, subangular blocky structure that parts to moderate, fine and very fine, granular; friable; medium acid; gradual, smooth boundary.

B1—29 to 34 inches, brown (10YR 4/3) clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; moderate, fine and medium, subangular blocky structure; friable; medium acid; diffused, smooth boundary.

B21—34 to 40 inches, brown (10YR 4/3) clay loam, very dark grayish-brown (10YR 3/2) coatings on ped faces; few, fine, distinct mottles of strong brown (7.5YR 5/6); moderate medium and coarse, subangular blocky structure; friable; few coarse sand grains; slightly acid; clear, smooth boundary.

B22—40 to 55 inches, mottled, dark yellowish-brown (10YR 4/4) and strong-brown (7.5YR 5/6) heavy clay loam; dark grayish-brown (10YR 4/2) coatings on ped faces; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; thin, discontinuous clay films; few roots; few fine pores; many coarse sand grains; slightly acid; diffused, smooth boundary.

B3—55 to 70 inches, yellowish-brown (10YR 5/4) sandy clay loam; dark-brown (10YR 3/3) coatings on ped faces; weak, coarse, prismatic structure; firm; few, fine, soft reddish-brown and yellowish-brown oxides and few soft black oxides of iron and manganese; many coarse sand grains; common pebbles; neutral.

The A horizon is typically loam but ranges to clay loam. It ranges from 24 to 32 inches in thickness. The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2). The A3 horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). The B1 horizon ranges from loam to clay loam. The B2 horizon is light clay loam or clay loam above a depth of 40 inches but ranges to heavy clay loam below that depth. The B3 horizon ranges from loam to sandy clay loam and light clay loam. Depth to the C horizon ranges from 50 to 80 inches.

Olmitz soils are associated with Ely, Judson, Nevin, and Wiota soils. They have more sand and less silt in their B horizon than Judson, Wiota, Nevin, and Ely soils. Olmitz soils are not as poorly drained as Ely and Nevin soils.

Olmitz loam, 2 to 5 percent slopes (273B).—This soil is on straight or slightly concave foot slopes or convex alluvial fans in valleys below uplands. The soils formed in alluvium. Areas are generally 5 to 20 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas with 5 to 12 inches of recently deposited loamy material on the surface. These deposits are generally lighter in color and lower in content of organic matter than the surface layer in the profile described as representative for the series.

Runoff is medium to slow on this soil. Slight hazards of erosion and wetness exist during short periods in spring because of runoff water from adjacent uplands. The surface layer is very friable and easy to till. Tilth is good.

This soil is used intensively for and is well suited to corn, soybeans, and hay. Capability unit IIe-2; woodland suitability group 2o1.

Olmitz loam, 5 to 9 percent slopes (273C).—This soil is on straight or slightly concave foot slopes or on convex alluvial fans. It is in valleys below soils that formed in glacial till, sandstone, or eolian sand. Areas of this soil are often rather long and narrow and are 5 to 15 acres in size.

Included with this soil in mapping are small areas of Gara, Lindley, and Caleb soils. In places on the lower part of foot slopes or on alluvial fans, the surface layer has 7 to 18 inches of lighter colored loamy overwash material. In these areas the soil is generally lower in content of organic matter and poorer in tilth than the representative Olmitz soil. In places these deposits of loamy material cause damage to crops in spring.

Runoff is medium on this soil. The soil loss by erosion is offset by the accumulation of loamy sediment from the adjacent soils upslope. The surface layer is very friable and easy to work.

This soil is used for and is well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 2o1.

Ossian Series

The Ossian series consists of deep, poorly drained soils that formed in silty alluvium on nearly level bottom lands and low stream benches. Slopes are 0 to 2 percent. The native vegetation was grass.

In a representative profile the surface layer is black silt loam and light silty clay loam about 16 inches thick. The subsoil extends to a depth of 46 inches. It is dark-gray and gray light silty clay loam that has mottles of yellowish brown. The underlying material is light brownish-gray light silty clay loam that also has mottles of yellowish brown. Concretions of iron and manganese are in the lower part of the subsoil and in the underlying material.

Available water capacity is high in these soils. Permeability is moderate. They have a high water table in spring and are often flooded by stream overflow in unprotected areas. Tile drainage is needed for timely farming operations. The surface layer is neutral in reaction and is high in content of organic matter. The subsoil is low to medium in available phosphorus and low in available potassium.

Where drainage is adequate these soils are well suited to row crops and hay. Ossian soils that are not drained and protected from flooding are generally used for pasture.

Representative profile of Ossian silt loam, 0 to 2 percent slopes, in a cultivated area about 450 feet south and 450 feet east of the NW. corner of the SW¼SE¼ sec. 2, T. 75 N., R. 15 W.:

Ap—0 to 7 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.

A1—7 to 16 inches, black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) when dry; weak, medium and fine, granular structure; friable; few black (N 2/0) worm casts; neutral; gradual, smooth boundary.

B1g—16 to 25 inches, dark-gray (10YR 4/1) light silty clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure that parts to weak, medium and fine, granular; friable; neutral; clear, smooth boundary.

B21g—25 to 37 inches, dark-gray (10YR 4/1) light silty clay loam; common yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure that parts to weak, fine, subangular blocky; friable; few, thin, discontinuous clay films and root channels in lower part of horizon; common iron and manganese concretions; common fine pores; slightly acid; gradual, smooth boundary.

B22g—37 to 46 inches, gray (10YR 5/1) light silty clay loam; common, fine and medium, distinct strong-brown (7.5YR 5/6) mottles; weak, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; few, thin, discontinuous clay films and root channels; common pinholes; slightly acid; diffused, smooth boundary.

C1—46 to 66 inches, light brownish-gray (2.5Y 6/2) light silty clay loam, light gray (10YR 7/2) when dry; common, medium, distinct yellowish-brown (10YR 5/6) mottles; weak, medium and coarse, prismatic structure; friable; few black (5YR 2/1) manganese concretions increasing with depth; common pinholes to a depth of 56 inches; neutral; diffused, smooth boundary.

C2—66 to 96 inches, light brownish-gray (2.5Y 6/2) light silty clay loam; many, medium, distinct yellowish-brown (10YR 5/6) mottles; massive, some vertical cleavage; friable; common, medium, black (5YR 2/1) manganese concretions; neutral.

The A horizon ranges in thickness from 12 to 20 inches. It is typically black (10YR 2/1) or (N 2/0) but ranges to very dark gray (10YR 3/1). It is typically silt loam but ranges to silty clay loam in some places. The depth to mottles ranges from 14 to 30 inches.

Ossian soils are associated with Amana, Colo, Kennebec, and Nodaway soils. They have a grayer B horizon than Amana, Kennebec, and Colo soils. Ossian soils have a darker A horizon and are not as stratified as Nodaway soils.

Ossian silt loam, 0 to 2 percent slopes (489).—This soil is on bottom lands and low benches. It is in the valleys of the larger streams. Areas generally have irregular boundaries and are 25 to more than 100 acres in size. This soil has the profile described as representative for the Ossian series.

Included with this soil in mapping are small areas of Amana, Colo, Zook, Kennebec, and Nodaway soils. These included soils make up about 20 percent of a mapping unit.

Runoff is slow on this soil. Wetness is a problem in unprotected areas in spring because of stream overflow. The surface layer is friable and is easy to till.

This soil is well suited to corn, soybeans, and hay where it is protected. Unprotected areas are generally used for pasture. Capability unit IIw-2; woodland suitability group 5w3.

Otley Series

The Otley series consists of deep, moderately well drained soils that formed in loess. They are on uplands where slopes are convex and on high stream benches. Slopes are 2 to 14 percent. The native vegetation was grass.

In a representative profile the surface layer is very dark grayish-brown to very dark brown light silty clay loam about 16 inches thick. The subsoil is silty clay loam that extends to a depth of 54 inches. It is brown with mottles of light brownish gray in the upper part and is light brownish gray with mottles of brown in the lower part. The underlying material is light brownish-gray heavy silt loam that has mottles of yellowish brown.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is generally slightly acid unless it has been limed, and it is moderate in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium. Otley soils are subject to erosion.

If these soils are properly managed, they are well suited or moderately well suited to row crops and hay.

Representative profile of Otley silty clay loam, 2 to 5 percent slopes, in a cultivated area 75 feet east of gate that is 230 feet north of the SW. corner of the NE¼NE¼ sec. 28, 70 feet south of diagonal road in the NE¼NE¼ sec. 28, T. 75 N., R. 15 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) when dry; weak, medium, granular structure; friable; common roots; neutral; clear, smooth boundary.

A1—8 to 12 inches, very dark brown (10YR 2/2) light silty clay loam, grayish brown (10YR 5/2) when dry; moderate, medium, granular structure; friable; common roots; slightly acid; clear, smooth boundary.

A3—12 to 16 inches, very dark brown (10YR 2/2) light silty clay loam, grayish brown (10YR 5/2) when dry; moderate, coarse, granular structure; friable; common roots; slightly acid; clear, smooth boundary.

B1—16 to 21 inches, brown (10YR 4/3) silty clay loam, very dark brown (10YR 2/2) coatings on ped faces; moderate, fine, subangular blocky structure; friable; common roots; slightly acid; clear, smooth boundary.

B21t—21 to 27 inches, brown (10YR 4/3) heavy silty clay loam, very dark grayish-brown (10YR 3/2) coatings on ped faces; weak, fine, prismatic structure that parts to moderate, fine and medium, subangular blocky; firm; thin, discontinuous clay films; common roots; slightly acid; clear, smooth boundary.

B22t—27 to 32 inches, brown (10YR 4/3) silty clay loam, very dark grayish-brown (10YR 3/2) coatings on ped faces; common, fine mottles of light brownish gray (2.5Y 6/2); weak, fine, prismatic structure that parts to moderate, medium, subangular blocky; firm; thick, discontinuous clay films; common roots; few soft dark oxides; slightly acid; gradual, smooth boundary.

B23—32 to 41 inches, brown (10YR 4/3) silty clay loam, dark grayish-brown (10YR 4/2) coatings on ped faces; common, distinct mottles of light brownish gray (10YR 6/2) and yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to moderate, medium, subangular; friable; thin, discontinuous clay films; common roots; few soft dark oxides; slightly acid; gradual, smooth boundary.

B3t—41 to 54 inches, light brownish-gray (2.5Y 6/2) light silty clay loam, dark-brown (10YR 4/3) coatings on ped faces; common, fine, prominent mottles of brown (7.5Y 4/4); weak, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; thin, discontinuous clay films; few roots; few soft dark oxides; slightly acid; diffused, smooth boundary.

C—54 to 70 inches, light brownish-gray (2.5Y 6/2) heavy silt loam; common, fine, distinct mottles of yellowish brown (10YR 5/6); massive; friable; few roots to a depth of 65 inches; common, fine, tubular pores and root channels; slightly acid.

The A horizon ranges from 10 to 20 inches in thickness. The Ap horizon is generally very dark grayish brown (10YR 3/2) or very dark brown (10YR 2/2). The B1 horizon is brown (10YR 4/3) or dark grayish-brown (10YR 4/2) light or medium silty clay loam. The B2t horizon is medium or heavy silty clay loam. Content of clay ranges from 36 to 42 percent.

Clay films range from thin and discontinuous to moderately thick and continuous. The B3 horizon is light to medium silty clay loam. It has mottled colors that range in hue from 2.5Y to 7.5YR and in value from 4 to 6. Depth to the C horizon ranges from 48 to 72 inches. The thickness of the loess in which Otley soils formed ranges from about 4 to 8 feet.

Otley soils are associated with Downs, Ladoga, Mahaska, and Nira soils. They have a browner B2 horizon and a greater depth to mottles than Mahaska soils. Otley soils have a thicker dark A horizon than Ladoga and Downs soils, and they lack the A2 horizon of these soils and are less acid. Otley soils have more clay in the B horizon than Downs and Nira soils.

In some areas moderately eroded Otley soils have a surface layer that is thinner than the minimum for the defined range of the series, but this does not significantly affect their use and management.

Otley silty clay loam, 2 to 5 percent slopes (281B).—This soil is on convex ridges and side slopes. It is generally along the edges of upland divides and between waterways in the higher parts of uplands. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 20 to more than 60 acres in size. This soil has the profile described as representative for the Otley series.

Included with this soil in mapping are small areas of Mahaska, Nira, and Ladoga soils.

Runoff is medium on this soil. Wetness is a problem in some places at the heads of drainageways. The hazard of water erosion is slight. The surface layer is friable and easy to till. Tilth is good.

This soil is well suited to and is mainly used for corn, soybeans, and hay. Capability unit IIe-1; woodland suitability group 1o1.

Otley silty clay loam, 5 to 9 percent slopes (281C).—This soil is on convex ridges and side slopes of the uplands. It is generally on the edges of upland divides and between waterways above the loess-till contact line. Areas of this soil are generally quite long and narrow, have irregular boundaries, and are 20 to more than 40 acres in size.

This soil has a profile similar to that described as representative of the Otley series, but the thickness of the combined surface layer and subsoil and the depth to the maximum clay in the subsoil are slightly less than those in that profile.

Included with this soil in mapping are small areas of Nira, Ladoga, and Clearfield soils.

Runoff is medium on this soil. The hazard of water erosion is moderate. The surface layer is friable and easy to till. Tilth is good.

This soil is well suited to corn, soybeans, and hay. Capability unit IIIe-1; woodland suitability group 1o1.

Otley silty clay loam, 5 to 9 percent slopes, moderately eroded (281C2).—This soil is on convex ridges and side slopes of the uplands. It is generally on the edges of upland divides and between waterways above the loess-till contact line. Areas of this soil are generally quite long and narrow, have irregular boundaries, and are 10 to more than 60 acres in size.

This soil has a profile similar to that described as representative of the Otley series, but the surface layer in this soil is 3 to 7 inches thick, lighter in color, and lower in content of organic matter. The depths to the point of maxi-

mum clay content, to mottles, and to the underlying material are less in this soil than in the one described as representative of the series.

Included with this soil in mapping are small areas of severely eroded Otley soil on side slopes and nose slopes. Also included are small areas of Nira, Ladoga, and Clearfield soils.

Runoff is medium on this soil. The hazard of water erosion is moderate. The friability of the plow layer depends upon its content of organic matter and the amount of clay from the subsoil that has been mixed into it. This also affects the tilth and ease of tillage.

This soil is moderately well suited to corn, soybeans, and hay where it is properly managed. Capability unit IIIe-1; woodland suitability group 1o1.

Otley silty clay loam, 9 to 14 percent slopes (281D).—This soil is on convex ridges and side slopes in the uplands. It is generally on the edges of upland divides, circling hillsides and entering upland drainageways in areas that are generally rather long and narrow and somewhat parallel to the contour. The areas generally have irregular boundaries and are 20 to more than 50 acres in size.

This soil has a profile similar to that described as representative for the Otley series, but the surface layer and subsoil of this soil are thinner. Also, the depth to the point of maximum clay and the content of clay in the subsoil are less in this soil.

Included with this soil in mapping are small areas of Ladoga, Clarinda, and Shelby soils.

Runoff is rapid on this soil. The hazard of water erosion is severe. The surface layer is friable and easy to till.

This soil is moderately suited to corn, soybeans, and hay where it is properly managed. Capability unit IIIe-2; woodland suitability group 1o1.

Otley silty clay loam, 9 to 14 percent slopes, moderately eroded (281D2).—This soil is on convex ridges and side slopes in the uplands. It is generally on the edges of upland divides, circling hillsides and entering upland drainageways in areas that are generally rather long and narrow and somewhat parallel to the contour. Areas have irregular boundaries and are 20 to more than 50 acres in size.

This soil has a profile similar to that described as representative for the Otley series, but the surface layer of this soil is 3 to 7 inches thick, lighter in color, and lower in content of organic matter. Also, the depths to the point of maximum clay content, to mottles, and to the underlying material are less in this soil.

Included with this soil in mapping are small areas of severely eroded Otley soil. Also included are small areas of Ladoga, Clarinda, Armstrong, and Shelby soils.

Runoff is rapid on this soil. The hazard of water erosion is severe. The friability of the plow layer depends upon its content of organic matter and the amount of clay from the subsoil that has been mixed into it. This also affects the tilth and ease of tillage.

This soil is moderately suited to corn, soybeans, and hay where it is properly managed. Capability unit IIIe-2; woodland suitability group 1o1.

Otley silty clay loam, benches, 2 to 5 percent slopes (T281B).—This soil is on convex loess-covered benches in the valleys of the larger streams. It is generally along the edges of the broad benches in areas 10 to 30 acres in size.

This soil has a profile similar to that described as representative for the Otley series, but it is underlain by alluvium at a depth of 7 to 10 feet.

Included with this soil in mapping are small areas of Mahaska and Ladoga soils.

Runoff is medium on this soil. Flooding caused by stream overflow is not a hazard on this soil, but in some places the soil receives runoff water from soils upslope. The hazard of erosion is slight. The surface layer is friable and easy to till. Tilth is good.

This soil is well suited to corn, soybeans, and hay. Capability unit IIe-1; woodland suitability group 1o1.

Otley silty clay loam, benches, 5 to 9 percent slopes, moderately eroded (T281C2).—This soil is on convex loess-covered benches in the valleys of the larger streams. Areas are generally 5 to 20 acres in size. Those on edges of benches are quite long and narrow.

This soil has a profile similar to that described as representative for the Otley series, but it has a thinner and lighter colored surface layer and is underlain by alluvium at a depth of 5 to 10 feet.

Included with this soil in mapping are small areas of severely eroded Otley soil and Ladoga and Downs soils.

Runoff is rapid on this soil. The hazard of water erosion is moderate.

This soil is moderately suited to corn, soybeans, and hay if it is properly managed. Capability unit IIIe-1; woodland suitability group 1o1.

Pershing Series

The Pershing series consists of deep, somewhat poorly drained and moderately well drained soils that formed in loess. These soils have convex slopes and are on uplands in the southwestern part of the county. Slopes are 2 to 9 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark grayish-brown silt loam about 8 inches thick. The subsurface layer is dark grayish-brown silt loam about 7 inches thick. The subsoil generally extends to a depth of about 72 inches. It is dark grayish-brown and brown silty clay loam and light silty clay above a depth of 38 inches. Mottles of yellowish brown are between depths of 24 and 38 inches. The subsoil is mottled, light brownish-gray, grayish-brown, yellowish-brown, and strong-brown heavy silty clay loam between depths of 38 and 54 inches.

Available water capacity is high in these soils. Permeability is slow. The surface layer is generally medium acid unless it has been limed and is moderate in content of organic matter. The subsoil is high in available phosphorus and very low in available potassium in most places.

Pershing soils are subject to erosion. Under proper management they are suited to row crops and hay.

Representative profile of Pershing silt loam, 2 to 5 percent slopes, in a cultivated area 490 feet east and 36 feet south of the NW. corner of the NW¼ sec. 31, T. 74 N., R. 17 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; friable; medium acid; clear, smooth boundary.

A21—8 to 11 inches, dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, platy structure that parts to weak, fine and medium, granular; friable; medium acid; clear, smooth boundary.

A22—11 to 15 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, medium, subangular blocky structure that parts to weak, fine, platy; friable; strongly acid; gradual, smooth boundary.

B1—15 to 24 inches, dark grayish-brown (10YR 4/2) silty clay loam; moderate, fine, blocky structure; friable; common very pale brown (10YR 7/3) silt coatings on ped faces; very strongly acid; gradual, smooth boundary.

B21t—24 to 38 inches, dark grayish-brown (2.5Y 4/2) and brown (10YR 4/3) light silty clay; common, fine, faint mottles of yellowish brown (10YR 5/6); grayish-brown (10YR 5/2) coatings on ped faces; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; continuous clay films on vertical faces of prisms; few black (10YR 2/1) organic stains; few dark oxides in lower part; very strongly acid; gradual, smooth boundary.

B22t—38 to 54 inches, mottled, light brownish-gray (2.5Y 6/2), grayish-brown (2.5Y 5/2), yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) heavy silty clay loam; brown (10YR 4/3) coatings on ped faces; weak, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; moderately thick, discontinuous clay films; few iron and manganese oxides; strongly acid.

The A1 horizon ranges from 6 to 10 inches in thickness. It is very dark grayish brown (10YR 3/2) or very dark gray (10YR 3/1). The A2 horizon is typically dark grayish brown (10YR 4/2), but in some places it is grayish brown (10YR 5/2). The B1 horizon is light or medium silty clay loam. Maximum content of clay is 42 to 45 percent in the B2t horizon. Depth to the C horizon ranges from 64 to 80 inches.

Pershing soils are associated with Grundy soils and, like Givin and Ladoga soils, formed in loess. They have a thinner A1 horizon than Grundy soils, and Grundy soils lack an A2 horizon. Pershing soils have a thicker dark A horizon than Weller soils. Pershing soils have a higher content of clay in the B2 horizon than Givin and Ladoga soils.

Pershing silt loam, 2 to 5 percent slopes (131B).—This gently sloping soil is on convex ridges and side slopes in the uplands. It is also along the edges of upland divides. Areas of this soil are generally rather long and narrow, have irregular boundaries, and are 20 to more than 40 acres in size. This soil has the profile described as representative for the Pershing series.

Included with this soil in mapping are small areas of a similar soil that has a thinner surface layer.

Runoff is medium on this soil. Wetness is generally a problem around the heads of drainageways in spring. The hazard of water erosion is slight. The surface layer is friable and easy to till. Tilth is good. Soil compaction may be a problem if this soil is tilled when it is too wet.

This soil is well suited to corn, soybeans, and hay. Capability unit IIe-3; woodland suitability group 4w1.

Pershing silt loam, 5 to 9 percent slopes, moderately eroded (131C2).—This moderately sloping soil is on convex ridges and side slopes in the uplands. It is generally along the edges of upland divides. Areas are generally quite long and narrow, have irregular boundaries, and are 20 to more than 40 acres in size.

This soil has a profile similar to that described as representative for the Pershing series, but the surface layer of this soil is thinner, lighter in color, and lower in content of organic matter.

Included with this soil in mapping are small areas of severely eroded Pershing soil.

Runoff is medium on this soil. The hazard of water erosion is moderate. The plow layer is friable or firm depending upon the amount of clay from the upper part of the subsoil that has been mixed into it. This factor also affects the tilth and ease of tillage. Soil compaction may be a concern if this soil is tilled when it is too wet.

This soil is moderately suited to corn, soybeans, and hay where it is properly managed. Capability unit IIIe-3; woodland suitability group 4w1.

Radford Series

The Radford series consists of deep, somewhat poorly drained soils that formed in silty alluvium. These soils are on flood plains and drainageways. Slopes are 0 to 2 percent. The native vegetation was grass.

In a representative profile the surface layer is black silt loam 12 inches thick. The next layer extends to a depth of 29 inches. It is black silt loam that has a few very thin horizontal layers of dark grayish-brown silt loam. Below a depth of 29 inches is a buried soil. The surface layer of the buried soil is black silty clay loam in the upper part and black light silty clay in the lower part. The subsoil of the buried soil is black silty clay loam between depths of 60 and 70 inches. The material below this depth is gray silty clay loam.

Available water capacity is high in these soils. Water often overflows on these soils in spring where areas are not protected. Permeability is moderate to a depth of about 29 inches and moderately slow between depths of 29 and 60 inches. The surface layer is high in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium.

Where these soils are adequately drained and protected from overflow, they are well suited to row crops and hay.

Representative profile of Radford silt loam, 0 to 2 percent slopes, in a meadow 800 feet north and 60 feet east of the SW. corner of sec. 22, T. 77 N., R. 16 W.:

A1—0 to 12 inches, black (10YR 2/1) silt loam, grayish brown (10YR 5/2) when dry; weak, medium and fine, platy structure; friable; neutral; abrupt, smooth boundary.

C—12 to 29 inches, black (10YR 2/1) silt loam, grayish brown (10YR 5/2) when dry; few, thin, horizontal layers of dark grayish brown (10YR 4/2); weak, medium and fine, platy structure; friable; neutral; abrupt, smooth boundary.

IIA1b—29 to 39 inches, black (N 2/0) heavy silty clay loam; gray (10YR 5/1) when dry; moderate, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

IIA3b—39 to 60 inches, black (N 2/0) light silty clay; weak, medium, subangular blocky structure that parts to moderate, medium, granular; friable; neutral; gradual, smooth boundary.

IIBb—60 to 70 inches, black (10YR 2/1) silty clay loam, gray (5Y 5/1) when dry; moderate, fine, subangular blocky structure; firm; neutral; gradual, smooth boundary.

IICb—70 to 88 inches, gray (5Y 5/1) silty clay loam; few, fine, prominent mottles of light olive brown; massive; friable; neutral.

The A1 horizon ranges from 10 to 20 inches in thickness. It is typically black (10YR 2/1), but the Ap horizon ranges to very dark grayish brown (10YR 3/2). Depth to the buried soil is typically about 30 inches but ranges from 24 to 40 inches.

Radford soils are associated with Colo, Kennebec, and Zook soils. They are more stratified than Colo and Kennebec soils, which do not have a dark buried soil within a depth of 60 inches. Above the buried soil, Radford soils are lower in content of clay than Zook soils and are more stratified.

Radford silt loam, 0 to 2 percent slopes (467).—This soil is on slightly concave or nearly level drainageways and bottom lands. Areas of this soil in drainageways are generally quite long and narrow, but areas on larger bottom lands are irregular in shape. Areas are generally somewhat parallel to the stream channel and are 20 to 40 acres in size. This soil has the profile described as representative for the Radford series.

Included with this soil in mapping are small areas of Colo and Zook soils.

Runoff is slow on this soil. The surface layer is friable and easy to till under proper moisture conditions. Wetness caused by overflow water is a concern in spring in unprotected areas.

This soil is well suited to corn, soybeans, and hay if it is protected or adequate drainage is provided. Capability unit IIw-5; woodland suitability group 5w2.

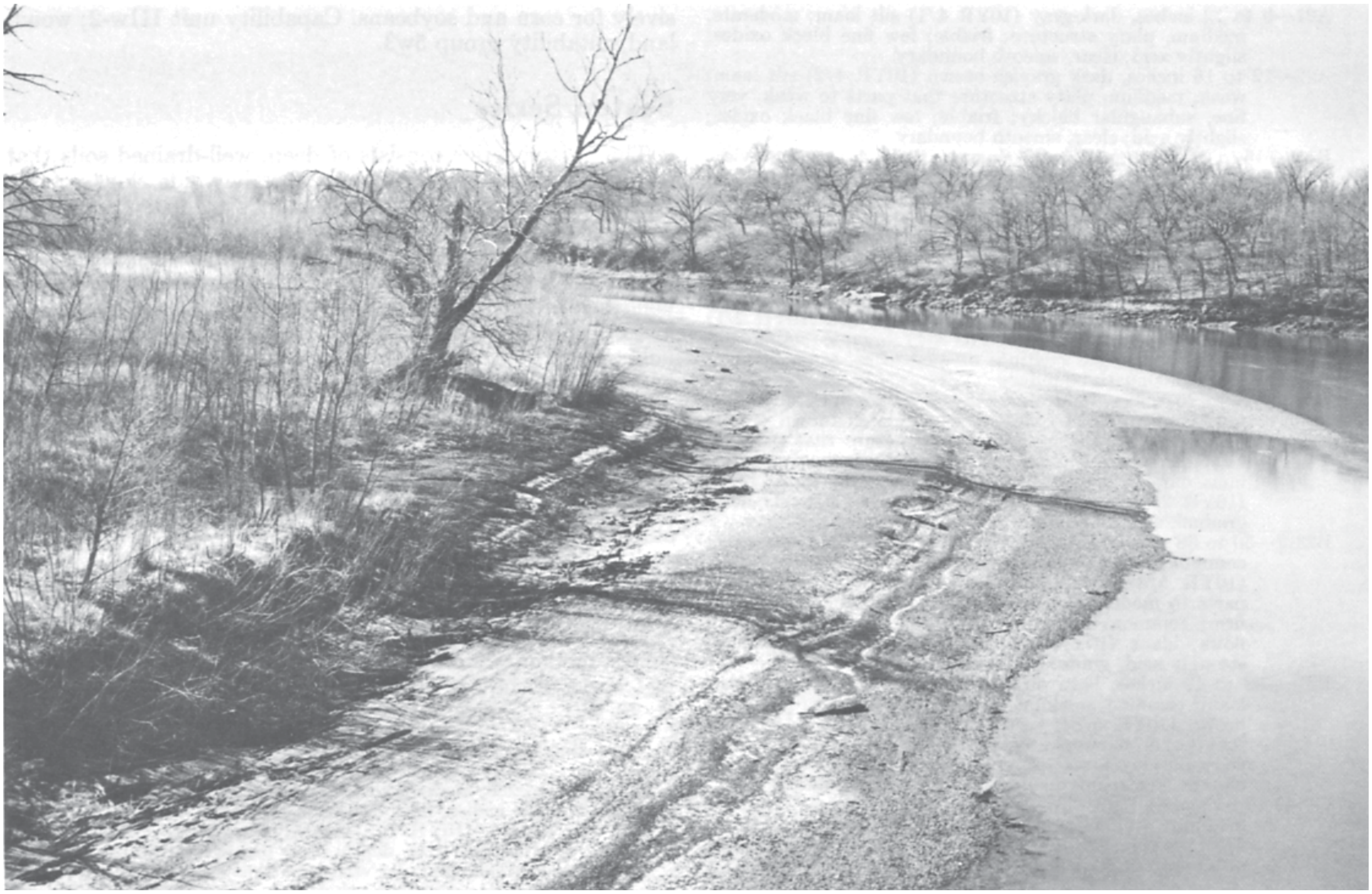


Figure 17.—**Typical area of Riverwash. Nodaway-Alluvial land complex is along left side of the riverbank.**

Riverwash

Riverwash (53) consists of islands of sand and some gravel within the river channel and similar deposits along the banks of the Des Moines and Skunk Rivers (fig. 17). Streambank deposits of Riverwash are associated with Alluvial land but are generally at lower elevation. When the river is high, most areas of Riverwash are under water. In the past these areas have changed in shape and size with changes in the river channel. Areas of Riverwash generally have no vegetation, but a few support thickets of small willows. The flow of the Des Moines River is now controlled by the Red Rock Dam and Reservoir, which is a few miles west of Mahaska County, and areas of Riverwash are expected to be more stable and to support more vegetation. Areas of Riverwash are elongated in the direction of the stream channel and are 2 to 20 acres in size.

Riverwash has no value for farming, and the position within or adjacent to the river channel limits it suitability as a source of sand and gravel for roads and other construction uses. Capability unit VIIs-3; woodland suitability group not assigned.

Rubio Series

The Rubio series consists of deep, poorly drained to very poorly drained soils that formed in loess. These soils are nearly level or are in slight depressions on broad upland divides and broad high stream benches. Slopes are less than 2 percent. The native vegetation was grass, trees, and sedges.

In a representative profile the surface layer is very dark gray silt loam 9 inches thick. The subsurface layer is silt loam and extends to a depth of 16 inches. It is dark gray in the upper part and dark grayish brown in the lower part. The subsoil extends to a depth of 49 inches. It is mottled dark-gray, grayish-brown, olive-gray, and olive silty clay in the upper part and light olive-gray silty clay in the middle. The lower part of the subsoil is light olive-gray light silty clay loam. The underlying material is light olive-gray silt loam.

Available water capacity is high in these soils. Permeability is slow to very slow. The surface layer is generally slightly acid unless it has been limed and is moderate in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium.

Rubio soils are wet in spring and need drainage to make timely farming operations possible. They are moderately well suited to row crops where they are drained.

Representative profile of Rubio silt loam, 0 to 2 percent slopes, in a cultivated area 135 feet east and 495 feet south of the NW. corner of NE¼NE¼ sec. 28, T. 74 N., R. 15 W.:

Ap—0 to 9 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A21—9 to 12 inches, dark-gray (10YR 4/1) silt loam; moderate, medium, platy structure; friable; few fine black oxides; slightly acid; clear, smooth boundary.

A22—12 to 16 inches, dark grayish-brown (10YR 4/2) silt loam; weak, medium, platy structure that parts to weak, very fine, subangular blocky; friable; few fine black oxides; slightly acid; clear, smooth boundary.

B1tg—16 to 20 inches, mottled dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) heavy silty clay loam; moderate, fine, subangular blocky structure; firm; thin, discontinuous clay films; continuous gray silt coatings on ped faces; few fine black oxides; slightly acid; clear, smooth boundary.

B21tg—20 to 26 inches, mottled, olive-gray (5Y 5/2) and olive (5Y 5/4) silty clay; strong, fine, angular and subangular blocky structure; firm; medium, discontinuous, dark grayish-brown (10YR 4/2) clay films; black (10YR 2/1) and very dark gray (10YR 3/1) organic stains and common gray silt coatings on ped faces; strongly acid; gradual, smooth boundary.

B22tg—26 to 30 inches, light olive-gray (5Y 6/2) light silty clay; few, fine, prominent mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that parts to strong, medium, subangular blocky; firm; nearly continuous dark grayish-brown (10YR 4/2) clay films; black (10YR 2/1) organic stains on ped faces; strongly acid; gradual, smooth boundary.

B23tg—30 to 38 inches, light olive-gray (5Y 6/2) light silty clay; common, fine, prominent mottles of yellowish brown (10YR 5/8); weak, medium, prismatic structure that parts to moderate, medium and coarse, angular blocky; firm; common dark grayish-brown clay films and clay flows; black (10YR 2/1) organic stains on ped faces; strongly acid; gradual, smooth boundary.

B3tg—38 to 49 inches, light olive-gray (5Y 6/2) light silty clay loam; common, medium, prominent mottles of yellowish brown (10YR 5/8); weak, medium, prismatic structure that parts to weak, coarse, subangular blocky; firm; common clay films and clay flows in root channels; few clay balls; strongly acid; diffused, smooth boundary.

C—49 to 96 inches, light olive-gray (5Y 6/2) silt loam; common, medium, prominent mottles of yellowish brown (10YR 5/8); massive; friable; common fine tubular pores; neutral at a depth of 60 inches.

The A1 horizon ranges from 6 to 10 inches in thickness. It is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The A2 horizon ranges in color from dark gray (10YR 4/1) to grayish brown (10YR 5/2). Depth to the B horizon ranges from 13 to 17 inches. The B2t horizon is generally heavy silty clay loam, but in places it has a thin layer of light silty clay in the upper part. Clay films range from thin discontinuous to thick continuous. Depth to the C horizon ranges from 40 to 64 inches.

Rubio soils are associated with Givin soils and formed in material similar to that of the Sperry and Taintor soils. They have a thinner A1 horizon than Sperry soils and lack the dark organic coatings on ped faces in the upper part of the B horizon that Sperry soils have. Rubio soils have a thinner A1 horizon and are lower in content of organic carbon than Taintor soils. Rubio soils have an A2 horizon while Taintor soils do not. Rubio soils are more poorly drained than Givin soils.

Rubio silt loam, 0 to 2 percent slopes (74).—This soil is in slight depressions or in nearly flat areas on broad upland divides and stream benches. Areas on benches are underlain by stratified alluvium between depths of 7 and 15 feet. The areas are irregular in shape and are generally 10 to 20 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of Givin and Taintor soils.

Runoff is very slow on this soil. In places water remains on the surface during wet periods. Drainage is needed for crop growth on this soil. The surface layer is friable. Under proper moisture conditions tilth is good, and the soil is moderately easy to till. The individual areas of this soil are rather small in size and are farmed with the adjoining soils.

This soil is moderately well suited to and is used intensively for corn and soybeans. Capability unit IIIw-2; woodland suitability group 5w3.

Seaton Series

The Seaton series consists of deep, well-drained soils that formed in loess. These soils are in valley side slopes of the Des Moines and Skunk Rivers. Slopes are 9 to 25 percent. The native vegetation was trees.

In a representative profile the surface layer is dark grayish-brown silt loam 6 inches thick. The subsurface layer is dark yellowish-brown silt loam 7 inches thick. The subsoil is silt loam and extends to a depth of 45 inches. It is brown or yellowish brown. The underlying material is yellowish-brown and brown silt loam that is calcareous below a depth of 60 inches. It contains some small shell fragments.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is typically medium acid unless it has been limed and is low or very low in content of organic matter. The subsoil is high in available phosphorus and very low in available potassium.

Strongly sloping Seaton soils are suited to crops. Steeper Seaton soils are better suited to and are usually used for hay, trees, or wildlife habitat.

Representative profile of Seaton silt loam, 9 to 14 percent slopes, moderately eroded, in a pasture 35 feet west and 240 feet north of the SE. corner of NE¼SE¼ sec. 23, T. 76 N., R. 16 W.:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 5/3) when dry; weak, fine, granular structure; very friable; medium acid; abrupt, smooth boundary.

A2—6 to 13 inches, dark yellowish-brown (10YR 4/4) silt loam, brown (10YR 5/3) when dry; weak, medium, platy structure to a depth of 8 inches and weak, fine and medium, granular structure between depths of 8 and 13 inches; very friable; thin, discontinuous, gray silt coatings on ped faces; some very dark grayish-brown (10YR 3/2) worm casts; medium acid, gradual, smooth boundary.

B21t—13 to 22 inches, brown (10YR 4/3) silt loam, brown (10YR 5/3) when dry; weak, medium, prismatic structure that parts to weak, fine and very fine, subangular blocky; very friable; few, thin, discontinuous dark brown (10YR 3/3) clay films; few gray silt coatings on ped faces; medium acid; gradual, smooth boundary.

B22—22 to 37 inches, brown (10YR 4/3) silt loam, slightly lighter colored ped faces; weak, medium, prismatic structure that parts to weak, fine and very fine, subangular blocky; friable; few, thin, gray silt coatings on ped faces; medium acid; gradual, smooth boundary.

B3—37 to 45 inches, yellowish-brown (10YR 5/4) silt loam; very thin, discontinuous, brown (10YR 4/3) coatings on ped faces; very weak, medium, prismatic structure; very friable; neutral; gradual, smooth boundary.

C1—45 to 60 inches, yellowish-brown (10YR 5/4) coarse silt loam, brown (10YR 4/3) in places on cleavage faces; massive, a few cleavage faces; very friable; few small shells between depths of 57 and 60 inches; neutral; gradual, smooth boundary.

C2—60 to 72 inches, yellowish-brown (10YR 5/4) and some brown (10YR 4/3) coarse silt loam; massive; very friable; many fragments of shells; mildly alkaline.

The A1 horizon ranges from 3 to 6 inches in thickness. It is very dark grayish brown (10YR 3/2) when uncultivated, but the Ap horizon ranges from dark grayish brown (10YR 5/3). The A2 horizon ranges from dark yellowish brown (10YR 4/4) to pale brown (10YR 6/3). Maximum content of clay in the B2 horizon typically is about 23 percent, but it ranges from 20 to 25 percent. Depth to the C horizon ranges from 42 to 60 inches. In places the C horizon is calcareous above a depth of 80 inches.

Seaton soils are associated with Chelsea, Clinton, and Fayette soils. They are lower in content of clay than Fayette and Clinton soils. They are more silty and less sandy than Chelsea soils.

Seaton silt loam, 9 to 14 percent slopes, moderately eroded (663D2).—This soil is on narrow ridges and on the upper part of convex side slopes that border the valleys of the larger streams. These slopes are dissected by eroded drainageways that are one hundred to several hundred feet apart. Areas of this soil are long and narrow, have irregular boundaries, and are generally 10 to 20 acres in size. This soil has the profile described as representative for the Seaton series.

Included with this soil in mapping are small areas of severely eroded soils and small areas of the more sandy Chelsea soil. These are shown on the soil map by a special symbol. Also included are small areas of a similar soil that is calcareous at or near the surface and has slopes of 5 to 14 percent. These are shown on the soil map by a symbol for calcareous soil.

Runoff is rapid on this soil. The hazards of water erosion and soil blowing are moderate or severe. The surface layer is low in content of organic matter and is very friable. Tilth is good.

This soil is moderately suited to corn and soybeans. It is well suited to hay, pasture, or trees. Capability unit IIIe-2; woodland suitability group 1o1.

Seaton silt loam, 14 to 18 percent slopes, moderately eroded (663E2).—This soil is on the upper part of convex side slopes that border the valleys of the larger streams. These slopes are dissected by eroded drainageways that are one hundred to several hundred feet apart. Areas of this soil are long and narrow, have irregular boundaries, and are 10 to 40 acres in size.

This soil has a profile similar to that described as representative for the Seaton series, but the surface layer of this soil is thinner.

Included with this soil in mapping are small areas of severely eroded soils and small areas of the more sandy Chelsea soil. These are shown on the soil map by a special symbol. Also included are small areas of a similar soil that is calcareous at or near the surface. These are shown on the soil map by a symbol for calcareous soil.

Runoff is rapid on this soil. The hazards of water erosion and soil blowing are severe. The surface layer is low in content of organic matter and is very friable. Tilth is good.

This soil is poorly suited to corn and soybeans. It is better suited to hay, pasture, or trees. Capability unit IVe-1; woodland suitability group 1o1.

Seaton silt loam, 18 to 25 percent slopes, moderately eroded (663F2).—This soil is on convex side slopes that border the valleys of the larger streams. These slopes are dissected by eroded drainageways that are one hundred to several hundred feet apart. Areas of this soil are long and narrow, have irregular boundaries, and are generally 10 to 30 acres or more in size.

This soil has a profile similar to that described as representative for the Seaton series, but the surface layer of this soil is thinner.

Included with this soil in mapping are small areas of severely eroded soil and small sandy areas. In place along the lower boundary of this mapping unit are small outcrops of sandstone, shale, or glacial till. These areas are shown on the soil map by special symbols.

Runoff is rapid on this soil. The hazards of water erosion and soil blowing are severe. The surface layer is low in content of organic matter and is very friable.

This soil is not suited to row crops. It is suited to pasture, trees, or wildlife habitat. Capability unit VIe-2; woodland suitability group 2r1.

Shelby Series

The Shelby series consists of deep, moderately well drained soils that formed in glacial till. These upland soils are generally on the lower part of hillsides or ridges. Slopes are 9 to 18 percent. The native vegetation was grass.

In a representative profile the surface layer is very dark grayish-brown loam 10 inches thick. The subsoil extends to a depth of 44 inches. It is brown clay loam in the upper part. Below this it is yellowish-brown heavy clay loam grading with depth to clay loam. Mottles of gray are in the lower part of the subsoil. The underlying material is mottled, yellowish-brown and light olive-gray light clay loam that contains soft dark oxides.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is moderate in content of organic matter. The subsoil is low in available phosphorus and high in available potassium.

Shelby soils are moderately well suited to row crops and well suited to hay or pasture.

Representative profile of Shelby loam, 9 to 14 percent slopes, moderately eroded, in a meadow 220 feet east and 370 feet north of the SW. corner of NE¼ sec. 11, T. 75 N., R. 17 W.:

A1—0 to 10 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry; moderate, fine, granular structure; friable; many roots; neutral; gradual, smooth boundary.

B1—10 to 15 inches, very dark grayish-brown (10YR 3/2) and brown (10YR 4/3) light clay loam; moderate, coarse, subangular blocky structure that parts to moderate, fine, subangular blocky; friable; many roots; medium acid; gradual, smooth boundary.

B21t—15 to 20 inches, brown (10YR 4/3) medium clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; moderate, fine, subangular blocky structure; friable; thin, continuous clay films; medium acid; clear, smooth boundary.

B22t—20 to 32 inches, yellowish-brown (10YR 5/6) clay loam; yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) coatings on ped faces; moderate, coarse, subangular blocky structure; firm; moderately thick, continuous clay films; common, medium and coarse sand particles; medium acid; clear, smooth boundary.

B3t—32 to 44 inches, yellowish-brown (10YR 5/4) clay loam; common, medium, distinct mottles of light gray (5Y 7/1); moderate, medium, subangular blocky structure; friable; thin, continuous clay films; many fine and few coarse sand grains; slightly acid; gradual, smooth boundary.

C—44 to 72 inches, mottled, yellowish-brown (10YR 5/6) and light olive-gray (5Y 6/2) light clay loam; massive; few soft dark oxides below a depth of 60 inches; neutral.

The A horizon is typically loam but ranges to light clay loam or silt loam. It ranges from 10 to 15 inches in thickness in areas where it is uneroded. This horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2). The B2t horizon is brown (10YR 4/3) to dark yellowish brown (10YR 4/4) in the upper part. Maximum content of clay is 32 to 35 percent in most areas, but soils having a thin horizon that is as much as 38 percent clay are present in places. The B3 horizon is yellowish-brown (10YR 5/4 or 5/6). Clay films on faces of peds in the B horizon are thin or moderately thick, and they are continuous or discontinuous. The C horizon is typically clay loam but is loam in places. It is mottled and has hues of 10YR, 2.5Y, and 5Y, values of 5 to 7, and chromas of 1 to 6. Depth to carbonates ranges from 40 to 72 inches. Depth to the C horizon is typically 40 to 50 inches.

Shelby soils are associated with Clarinda and Lamoni soils and formed in parent material similar to those of the Gara and Lindley soils. They have a thicker A1 horizon than Gara and Lindley soils and, unlike these soils, lack an A2 horizon. Shelby soils have a

B horizon that is browner and lower in content of clay than Clarinda and Lamoni soils.

Shelby loam, 9 to 14 percent slopes, moderately eroded (24D2).—This soil is on convex side slopes; on some low, narrow ridgetops; and around the heads of drainageways. It has many hillside waterways and often extends along hillsides and around nose slopes. Pebbles and stones are common in the plow layer. Areas of this soil are generally quite long and narrow, have irregular boundaries, and are 5 to 25 acres in size.

This soil has the profile described as representative for the Shelby series. In many places the surface layer is 3 to 7 inches thick. It is typically loam but in many places is light clay loam. The surface layer is thicker and darker along the concave parts of drainageways that receive sediment from soils at higher elevation.

Included with this soil in mapping, generally along the upper margin of areas or in pronounced coves, are small areas of soils with clayey subsoils. At the points of ridges, in some places, are spots of reddish weathered till. These areas are shown on the soil map by a special symbol. Also included are a few areas of uneroded or less eroded Shelby soil that are 5 to 10 acres in size and have a darker, deeper, lighter textured surface layer than this soil. Areas of severely eroded soil up to 10 acres in size are shown on the soil map by the symbol for severe erosion.

Runoff is rapid on this soil. The hazard of erosion is severe. The rate of water intake is moderately slow. Tilth is poor in places.

This soil is moderately well suited to row crops if erosion is controlled and management is good. Capability unit IVe-4; woodland suitability group 2o1.

Shelby loam, 14 to 18 percent slopes, moderately eroded (24E2).—This soil is on convex uplands. It is generally on the lower part of dissected slopes but can occupy the ridgetop and entire side slope. It is commonly in irregular bands or strips that extend along hillsides and around nose slopes horizontally. Where it is cultivated, pebbles and stones are common in the plow layer. Areas are generally 5 to 20 acres in size.

This soil has a profile similar to that described as representative for the Shelby series, but the eroded surface layer of this soil is dark-brown to brown loam or light clay loam 3 to 7 inches thick.

Included with this soil in mapping, generally along the upper margin of areas, are small spots of seasonally wet and seepy gray and reddish clayey soils that formed in weathered till. Also included are areas of uneroded or less eroded Shelby soil, a few acres in size, that have a darker, deeper, and lighter surface layer than this soil. Areas of severely eroded soil, a few acres in size, are shown on the soil map by the symbol for severe erosion. Narrow strips of alluvium along small drainageways are also included.

Runoff is rapid on this soil. The hazard of erosion is severe. The surface layer is friable and moderately easy to till.

This soil is used for crops in places, although it is better suited to pasture. It provides suitable sites for ponds. Capability unit IVe-4; woodland suitability group 2o1.

Sogn Series

The Sogn series consists of shallow, somewhat excessively drained soils that formed in loamy material overlying limestone bedrock. These soils have convex slopes. They are on uplands adjacent to the larger streams and rivers. Slopes are 18 to 40 percent. The native vegetation was grass.

In a representative profile the surface layer is about 14 inches thick over hard limestone. It is very dark brown silt loam in the upper 3 inches, very dark brown light silty clay loam with a few limestone fragments between depths of 3 and 10 inches, and dark-brown light silty clay loam with many limestone fragments between depths of 10 and 14 inches. Fractured hard limestone is at a depth of 14 inches.

Available water capacity is low in these soils. Permeability is moderate. The surface layer is mildly alkaline and is low in content of organic matter. The subsoil is very low in available phosphorus and potassium.

These soils are subject to erosion during hard rains. They are suited to pasture, trees, and wildlife habitat.

Representative profile of Sogn silt loam, 18 to 40 percent slopes, in a grassy area 20 feet east and 600 feet north of the SW. corner of SE¼ sec. 26, T. 75 N., R. 14 W.:

A11—0 to 3 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) when dry; moderate, medium, granular structure; friable; many roots; mildly alkaline; clear, smooth boundary.

A12—3 to 10 inches, very dark brown (10YR 2/2) light silty clay loam, very dark grayish brown (10YR 3/2) when dry; strong, fine and medium, granular structure; friable; common roots; few limestone fragments 1 to 2 inches thick; mildly alkaline; gradual, irregular boundary.

A3—10 to 14 inches, dark-brown (10YR 3/3) light silty clay loam, very dark grayish-brown (10YR 3/2) coatings on ped faces; strong, fine and medium, subangular blocky structure; friable; many rock fragments 1 to 4 inches thick; moderately alkaline; abrupt, irregular boundary.

R—14 inches, fractured hard white (2.5Y 8/2) limestone, violently effervescent; road cut has 2 to 4 feet of hard fractured limestone strata.

The solum ranges from 4 to 20 inches in thickness except for some narrow crevasses in which soil material is at depths below 20 inches. The A1 horizon is very dark brown (10YR 2/2) or very dark grayish-brown (10YR 3/2) silt loam, light silty clay loam, or loam. The A3 horizon, if present, is light silty clay loam, loam, or clay loam. The solum contains few to many hard fragments that are either limestone or calcareous sandstone.

Sogn soils are in landscapes similar to those of the Boone soils. They are more calcareous than Boone soils. Sogn soils are underlain by limestone, and Boone soils are underlain by sandstone.

Sogn silt loam, 18 to 40 percent slopes (412G).—This shallow soil has steep, convex slopes. It is on uplands in areas that border large streams. Areas of this soil are long and narrow and have irregular boundaries. They are generally less than 250 feet in width and less than 20 acres in size.

This soil has the profile described as representative for the Sogn series. The surface layer is mainly loam, silt loam, or light silty clay loam.

Included with this soil in mapping are small areas of a similar soil that has a weakly developed subsoil between depths of 14 and 20 inches. Also included are small areas of Clinton, Lindley, Fayette, Seaton, and Boone soils. Outcrops (fig. 18) and ledges of limestone over sandstone bedrock less than 50 feet wide are commonly included. The larger outcrops are shown on the map by a special symbol.

Runoff is rapid on this soil. The hazard of erosion is severe unless this soil is properly managed.

This soil is not suitable for cultivation. It is suited to pasture, trees, or wildlife habitat. Capability unit VIIs-1; woodland suitability group 5s1.

Sparta Series

The Sparta series consists of deep, excessively drained soils. They formed in sandy alluvium that was deposited by

Figure 18.—**Linestone outcrop along a road cut in an area of Sogn silt loam, 18 to 40 percent slopes.**

wind. These soils have mostly convex slopes. They are on uplands and low benches near the North Skunk River. Slopes are 4 to 14 percent. The native vegetation was grass.

In a representative profile the surface layer is about 18 inches thick. It is black loamy fine sand in the upper 11 inches and very dark grayish-brown loamy fine sand below. The brown loamy sand subsoil extends to a depth of 24 inches. The underlying material is dark yellowish-brown loamy sand that changes with depth to yellowish-brown medium and coarse sand.

Available water capacity is very low in these soils. Permeability is very rapid. The surface layer is low in content of organic matter. The subsoil is very low in available phosphorus and potassium. Sparta soils are droughty. Soil blowing and water erosion are hazards.

The less sloping Sparta soils are often farmed along with adjacent soils, and the steeper Sparta soils are used mainly for pasture.

Representative profile of Sparta loamy fine sand, 4 to 9 percent slopes, 198 feet east and 100 feet south of the SW. corner of NW¼ sec. 25, T. 76 N., R. 14 W.:

A11—0 to 11 inches, black (10YR 2/1) loamy fine sand, very dark grayish brown (10YR 3/2) when dry; weak, very fine, granular structure; very friable; medium acid; clear, smooth boundary.

A12—11 to 18 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) when dry; weak, fine, granular structure to single grained; very friable; medium acid; gradual, smooth boundary.

B—18 to 24 inches, brown (10YR 4/3) loamy sand, brown (10YR 5/3) when dry; weak, coarse, prismatic structure to single grained; very friable to loose; medium acid; gradual, smooth boundary.

C1—24 to 35 inches, dark yellowish-brown (10YR 4/4) loamy sand; single grained; loose; medium and coarse sand dominant; medium acid; gradual, smooth boundary.

C2—35 to 60 inches, yellowish-brown (10YR 5/6) medium sand; single grained; loose; medium acid.

The A1 horizon is black (10YR 2/1) to very dark grayish-brown (10YR 3/2) fine sand to loamy fine sand. The B horizon is brown (10YR 4/3) to strong-brown (7.5YR 5/6) loamy fine sand, loamy sand, or fine sand. In places value is 3 to a depth of 30 inches. Thin iron bands of strong-brown (7.5YR 5/6) fine sandy loam are present in places at below a depth of 3 feet. These bands are higher in content of clay than the interbands.

Sparta soils formed in material similar to the parent material of the Chelsea soils. They have a thicker, darker A horizon than Chelsea soils. Iron bands are less evident in Sparta soils than in Chelsea soils.

Sparta loamy fine sand, 4 to 9 percent slopes (41C).—This soil is on convex ridge crests and side slopes and on slight rises, principally along the North Skunk River valley. In most places this soil is near areas of Otley or Ladoga soil, or is just upslope from bottom lands. Areas are irregular in shape and 2 to 10 acres in size.

This soil has the profile described as representative for the series, but in places the eroded surface layer of this soil is only 4 to 7 inches thick and is lighter in color.

Included with this soil is mapping are severely eroded spots that are shown on the soil map by the symbol used for this purpose. Also included are small areas of Sparta soil along drainageways that have a darker and thicker surface layer than the one in this soil.

Soil blowing and water erosion are hazards on this soil unless it is protected by vegetative cover (fig. 19).

This soil is poorly suited to corn and soybeans. It is moderately well suited to pasture or hay and is suited to wildlife habitat. Capability unit IVs-1; woodland suitability group 4s1.

Sparta-Otley complex, 5 to 9 percent slopes, moderately eroded (442C2).—This complex is on convex sloping or rolling uplands. It is mainly on the east or south sides of the valleys of the larger streams in the county. Slopes are short. Areas are irregular in shape and are generally 10 to 40 acres in size. The Sparta soil is generally in the more convex topography in oval or elongated areas, with the

Figure 19.—**Stripcropping for protection against soil blowing on Sparta loamy fine sand, 4 to 9 percent slopes.**

longer axis oriented in a northwest to southeast direction. It makes up about 30 to 50 percent of the complex and is more or less surrounded by Otley soil. Otley soil makes up about 30 to 50 percent of the complex. The rest is Downs and Ladoga soils.

Included with this complex in mapping are small, severely eroded areas of Sparta soil or of glacial till. These are shown on the soil map by the symbol for severe erosion. Also included are small areas of Downs and Ladoga soils.

Runoff is moderate on this soil. The hazards of water erosion and soil blowing are moderate to severe. The surface layer is friable or very friable and is easy to till. The sandy areas are droughty.

This complex is moderately well suited to corn and soybeans. It is well suited to hay or pasture. Capability unit IVs-1; woodland suitability group 4s1.

Sparta-Otley complex, 9 to 14 percent slopes, moderately eroded (442D2).—This complex is on convex sloping or rolling uplands. It is mainly on the east or south sides of the valleys of the larger streams in the county. Slopes are relatively short. Areas are irregular in shape and are generally 10 to 40 acres in size. The Sparta soil is in the more convex topography in oval or elongated areas, with the longer axis oriented in a northwest to southeast direction. It makes up about 30 to 50 percent of the complex and is more or less surrounded by Otley soil. Otley soil makes up about 30 to 50 percent of the complex. The rest is Ladoga and Downs soils.

Included with this complex in mapping are small, severely eroded areas of Sparta soil or of glacial till. These are shown on the soil map by the symbol for severe erosion. Also included are small areas of Downs and Ladoga soils.

Runoff is moderate to rapid on this soil. The hazards of water erosion and soil blowing are severe. The surface layer is friable or very friable and is easy to till. The sandy areas are droughty.

This complex is rather poorly suited to corn and soybeans. It is better suited to hay or pasture. Capability unit IVe-5; woodland suitability group 4s1.

Sperry Series

The Sperry series consists of deep, very poorly drained to poorly drained soils that formed in loess. These soils are in slight depressions on broad upland ridgetops. Slopes are less than 1 percent. The native vegetation was water-tolerant grasses and sedges.

In a representative profile the surface layer is very dark gray heavy silt loam 11 inches thick. The subsurface layer is gray silt loam that extends to a depth of 17 inches. The fine-textured subsoil is firm and extends to a depth of 53 inches. The upper part is very dark gray light silty clay that has a few mottles of yellowish brown, and the middle is dark-gray heavy silty clay loam that has common mottles of yellowish brown. The lower part of the subsoil is heavy silty clay loam that has mottles of yellowish brown and gray. The underlying material is light-gray silty clay loam that has many mottles of yellowish brown.

Available water capacity is high in these soils. Permeability is slow to very slow. Water stands on most areas of Sperry soils in wet seasons. The surface layer is neutral and is moderate to high in content of organic matter. The subsoil is very low in available phosphorus and potassium.

These soils are difficult to drain, but a surface opening into tile or a surface ditch is reasonably effective. Sperry soils are moderately well suited to row crops where they are adequately drained and poorly suited where they are not drained. Because these soils are in small areas surrounded by more productive soils, they are farmed along with the adjoining soils.

Representative profile of Sperry silt loam, 0 to 2 percent slopes, in a cultivated area 100 feet north and 100 feet east of the SW. corner of NE¼NW¼ sec. 3, T. 75 N., R. 17 W. (upland depression with slopes of less than 1 percent):

Ap—0 to 11 inches, very dark gray (10YR 3/1) heavy silt loam, gray (10YR 5/1) when dry; weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.

A2—11 to 17 inches, gray (10YR 5/1) silt loam, light gray (10YR 7/1) when dry; few, fine, faint mottles of very pale brown (10YR 7/3); moderate, fine and medium, platy structure that parts to weak, very fine, subangular blocky; friable; many very dark gray (10YR 3/1) organic stains on the bottoms of plates; medium acid; abrupt, smooth boundary.

B21tg—17 to 27 inches, very dark gray (10YR 3/1) light silty clay; black (10YR 2/1) coatings on ped faces; few, fine, distinct mottles of yellowish brown (10YR 5/4 and 5/6); weak, medium, prismatic structure that parts to moderate, fine and medium, subangular blocky; firm; many light-gray (10YR 7/1) silt coatings on ped faces; moderately thick, continuous clay films; medium acid; clear, smooth boundary.

B22tg—27 to 34 inches, dark-gray (10YR 4/1) heavy silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/4 and 5/6); very dark gray (10YR 3/1) coatings on ped faces; strong, fine, subangular blocky structure; firm; moderately thick, discontinuous clay films; slightly acid; gradual boundary.

B3tg—34 to 53 inches, mottled, yellowish-brown (10YR 5/4 and 5/6) and gray (5Y 5/1) heavy silty clay loam; moderate, medium and fine, subangular blocky structure; firm; thin, discontinuous clay films on ped faces; black (10YR 2/1) clay balls and clay flows in old root channels; neutral; gradual boundary.

C1g—53 to 62 inches, light-gray (5Y 7/2) heavy silty clay loam; common, fine mottles of yellowish brown (10YR 5/6); weak, coarse, subangular blocky structure; firm; neutral; gradual boundary.

C2g—62 to 96 inches, light-gray (5Y 7/1) medium silty clay loam, many, medium, prominent mottles of yellowish brown (10YR 5/6); massive; friable; neutral.

The solum ranges from 44 to 60 inches in thickness. The A1 horizon ranges from 8 to 13 inches in thickness and is very dark brown (10YR 2/2) to very dark gray (10YR 3/1). The A2 horizon is 6 to 8 inches in thickness. In places in the B2t horizon colors have a chroma of 2. This horizon has few to many mottles. The B22tg horizon is heavy silty clay loam or light silty clay.

Sperry soils are associated with Taintor and formed in material similar to that of Rubio soils. They have a thicker dark A1 horizon than Rubio soils. Sperry soils, unlike Taintor soils, have an A2 horizon that is more silty and is lighter in color than the A1 horizon. Sperry soils have a more abrupt increase in content of clay from the A2 horizon to the upper B2t horizon than Humeston soils. The content of clay does not remain as constant with increased depth in the B2t horizon in Sperry soils as it does in Humeston soils.

Sperry silt loam, 0 to 2 percent slopes (122).—This nearly level soil is in slight depressions on uplands. This soil is widely scattered and is in areas that have broad upland flats. Areas of this soil are 30 feet in diameter to 5 acres in size, may be irregular, but are generally somewhat circular.

This soil has the profile described as representative for the Sperry series. Surface water accumulates and stands on this soil for varying lengths of time, unless it is drained off. Farming operations are often delayed and young plants may be drowned because this soil is difficult to drain satisfactorily.

This soil is farmed with the adjoining, more productive soils. It is used primarily for corn and soybeans. Capability unit IIIw-2; woodland suitability group 5w3.

Spillville Series

The Spillville series consists of deep, somewhat poorly drained to moderately well drained soils that formed in loamy alluvium. These nearly level soils are on bottom lands of the larger streams in the county. Slopes are 0 to 2 percent. The native vegetation was grass.

In a representative profile the surface layer is 49 inches thick. It is very dark brown and very dark grayish brown loam in the upper part. The lower part is very dark grayish-brown light clay loam that has faint mottles of dark brown. The underlying material is very dark gray clay loam that has faint mottles of very dark grayish brown and a few soft yellowish-brown oxides.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is slightly acid unless it has been limed and is high in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium.

Spillville soils are occasionally subject to overflow in areas that are not protected. These soils are well suited to row crops and hay.

Representative profile of Spillville loam, 0 to 2 percent slopes, in a cultivated area 200 feet north and 600 feet west of the SE. corner of NE¼SW¼ sec. 36, T. 75 N., R. 17 W.:

Ap—0 to 10 inches, very dark brown (10YR 2/2) loam; weak, fine, granular structure; very friable; few roots; neutral; clear, smooth boundary.

A12—10 to 23 inches, very dark brown (10YR 2/2) loam; black (10YR 2/1) coatings on ped faces; weak, fine, subangular blocky structure that parts to weak, very fine, granular; very friable; few roots; neutral; clear, smooth boundary.

A13—23 to 37 inches; very dark grayish-brown (10YR 3/2) heavy loam; black (10YR 2/1) coatings on ped faces; weak, fine, subangular blocky structure that parts to weak, very fine, granular; friable; few roots; neutral; gradual, smooth boundary.

A14—37 to 49 inches, very dark grayish-brown (10YR 3/2) light clay loam; few, faint mottles of dark brown (10YR 3/3); very dark brown (10YR 2/2) coatings on ped faces; weak, medium, prismatic structure that parts to weak, medium, granular; friable; neutral; diffused, smooth boundary.

C—49 to 58 inches, very dark gray (10YR 3/1) clay loam; few, fine, faint mottles of very dark grayish brown (10YR 3/2); massive; few soft yellowish-brown oxides; neutral.

The A1 horizon ranges from 36 to 56 inches in thickness. It is typically black (10YR 2/1) but ranges to very dark grayish brown (10YR 3/2). Content of sand ranges from 25 to 40 percent to a depth of 30 inches and from 20 to 45 percent between depths of 30 and 60 inches.

Spillville soils are associated with the Amana, Colo, and Kennebec soils. They contain more sand between depths of 10 and 40 inches than Kennebec, Amana, and Colo soils.

Spillville loam, 0 to 2 percent slopes (485).—This nearly level to slightly undulating soil is on bottom lands of the larger streams in the county. Areas are generally irregular in shape and 10 to 30 acres in size. This soil has the profile described as representative for the Spillville series.

Included with this soil in mapping are small areas of Landes, Colo, Kennebec, and Spillville soils that have a sandy substratum. Areas of this soil with lighter colored sandy overwash 3 to 7 inches thick are indicated on the soil map by a special symbol.

Runoff is slow on this soil. Protection from overflow water is needed in places. The surface layer is very friable. Tilth is good. Where moisture conditions are proper, this soil is easy to till.

This Spillville soil is well suited to and is used intensively for corn, soybeans, and hay. Capability unit IIw-5; woodland suitability group 5w2.

Spillville loam, sandy substratum, 0 to 2 percent slopes (270).—This nearly level or slightly undulating soil is on bottom lands of the larger streams in the county. The areas are somewhat irregular in shape and are generally 5 to 15 acres in size.

This soil has a profile similar to that described as representative for the series, but has stratified fine sand at a depth of 40 to 50 inches.

Included with this soil in mapping in places, and especially in Scott township, is a soil that is loamy to a depth of about 33 inches and sandy below that depth.

Runoff is slow on this soil. This surface layer is friable and is easy to till. Tilth is good.

This soil is well suited to corn, soybeans, and hay. Capability unit IIw-5; woodland suitability group 5w2.

Taintor Series

The Taintor series consists of deep, poorly drained soils that formed in loess. These nearly level soils are on broad upland divides (fig. 20) and broad, high stream benches. Slopes are less than 2 percent. The native vegetation was grass and sedges.

In a representative profile the surface layer is black silty clay loam 17 inches thick. The subsoil extends to a depth of 61 inches. It is black light silty clay over mottled gray and light olive-brown light silty clay in the upper part. The middle and lower parts are light olive-gray silty clay loam that has mottles of yellowish brown and strong brown. The underlying material, below a depth of 61 inches, is light olive-gray and yellowish-brown silt loam.

Available water capacity is high in Taintor soils. Permeability is moderately slow. The surface layer is generally slightly acid unless it has been limed, and it is high in content of organic matter. The subsoil is very low in available phosphorus and potassium.

Taintor soils are wet in spring and need drainage to make timely farming operations possible. They are well suited to row crops and are used intensively for these crops where adequate drainage is provided.

Representative profile of Taintor silty clay loam, 0 to 2 percent slopes, in a cultivated area 198 feet west and 396 feet north of the SE. corner of SW¼SE¼ sec. 25, T. 74 N., R. 15 W.:

Ap—0 to 8 inches, black (N 2/0) silty clay loam, very dark grayish brown (10YR 3/2) when dry; weak, fine, granular structure; friable; few roots; neutral; abrupt, smooth boundary.

A1—8 to 17 inches, black (N 2/0) silty clay loam, very dark gray (10YR 3/1) when dry; weak, medium, prismatic structure that parts to moderate, fine, subangular blocky; friable; few roots; slightly acid; clear, smooth boundary.

B21t—17 to 22 inches, black (10YR 2/1) light silty clay; moderate, medium and fine, subangular blocky structure; firm; thin, discontinuous, very dark gray (10YR 3/1) clay films; slightly acid; gradual, smooth boundary.

B22tg—22 to 37 inches, mottled, dark-gray (5Y 4/1) and light olive-brown (2.5Y 5/6) light silty clay; moderate, fine, subangular blocky structure; firm; thick, continuous, very dark gray (10YR 3/1) clay films; slightly acid; gradual, smooth boundary.

B31tg—37 to 44 inches, light olive-gray (5Y 6/2) medium silty clay loam; common, medium, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure; firm; thin, continuous, very dark gray (10YR 3/1) clay flows; slightly acid; gradual, smooth boundary.

B32tg—44 to 61 inches, light olive-gray (5Y 6/2) silty clay loam; common, medium, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6 and 5/8);

Figure 20.—**Typical area of Taintor silty clay loam, 0 to 2 percent slopes, on broad upland divide southeast of Oskaloosa.**

massive; firm; common, thick clay flows in root channels; few soft dark reddish-brown oxides; slightly acid; gradual, smooth boundary.

Cg—61 to 96 inches, light olive-gray (5Y 6/2) and yellowish-brown (10YR 5/6) silt loam; massive; friable; slightly acid.

The A horizon is light or medium silty clay loam that ranges from 15 to 24 inches in thickness. It is black (N 2/0 or 10YR 2/1). If a B1 horizon is present, it is black (10YR 2/1) or very dark gray (10YR 3/1).

Taintor soils typically have a clay maximum of 40 to 45 percent in the upper B horizon. The B22tg horizon has mottled colors that range in hue from 5Y to 10YR, have a value of 4 or 5, and have chromas of 1 to 8. It has soft oxides and iron and manganese concretions in places. The clay films in the B2t horizon range from thick and continuous to thin and discontinuous. The B3 horizon is medium to light silty clay loam. It has mottled colors that range in hue from 5Y to 10YR, in value from 4 to 6, and in chroma from 1 to 8. The C horizon is silt loam or light silty clay loam. It has mottled colors that range in hue from 5Y to 7.5YR, in value from 5 to 6, and in chroma from 1 to 8.

Taintor soils are associated with Mahaska and Sperry soils and formed in material similar to the parent material of the Grundy, Haig, Mahaska, Rubio, and Sperry soils. They have a grayer B2t horizon than Mahaska and Grundy soils. Taintor soils have a thicker dark A1 horizon than Sperry or Rubio soils and lack an A2 horizon, which Sperry and Rubio soils have. They are lower in content of clay in the B2t horizon than Haig soils.

Taintor silty clay loam, 0 to 2 percent slopes (279).—This soil is on broad upland divides. Areas of this soil are generally long and narrow and have irregular boundaries. They are generally rather large, often ranging from 60 to more than 120 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping, and in places making up as much as 20 percent of the unit, are small areas of Haig soils. Small areas of Sperry soil in slight depressions are shown on the soil map by a special symbol. Also included are small areas of Mahaska soil along the boundaries of this Taintor soil.

Runoff is very slow on this soil. In places, water remains on the surface in wet periods. Drainage is needed for crop growth on this soil. The surface layer is friable if this soil is worked when it is not too wet. Where it is worked when too wet, the soil becomes firm and compaction becomes a problem. Under proper moisture conditions tilth is good and the soil is moderately easy to till.

This Taintor soil is well suited to and is used intensively for corn and soybeans. Capability unit IIw-1; woodland suitability group 5w3.

Taintor silty clay loam, benches, 0 to 2 percent slopes (T279).—This soil is on the large, nearly flat loess-covered benches in the valleys of major streams. The areas generally have irregular boundaries and are 10 to more than 40 acres in size.

This soil has a profile similar to that described as repre-

sentative for the Taintor series, but it is underlain by alluvium at a depth of 12 to 15 feet.

Included with this soil in mapping are small areas of Rubio, Givin, Mahaska, and Otley soils.

Runoff is very slow on this soil. This Taintor soil is not subject to flooding by stream overflow, but in places it receives runoff water from soils at higher elevations. Drainage is needed for crop growth on this soil. Under proper moisture conditions tilth is good and the soil is moderately easy to till.

This soil is well suited to corn and soybeans where it is adequately drained. Capability unit IIw-1; woodland suitability group 5w3.

Tuskeego Series

The Tuskeego series consists of deep, poorly drained soils that formed in silty alluvium. These soils are on nearly flat or slightly depressional bottom land. Slopes are generally less than 1 percent but range from 0 to 2 percent. The native vegetation was grass and trees.

In a representative profile the surface layer is very dark gray silt loam 9 inches thick. The subsurface layer extends to a depth of 21 inches. The upper part is dark-gray silt loam that has mottles of very dark grayish brown, and the lower part is grayish-brown light silty clay loam that has mottles of dark yellowish brown. The subsoil is gleyed and extends to a depth of 67 inches. The upper part is dark gray silty clay loam that has mottles of dark brown, and the middle is olive-gray light silty clay that has mottles of strong brown and has thick clay films on ped faces. The lower part is gray silty clay loam that has mottles of dark brown. The underlying material is light-gray silty clay loam that has mottles of strong brown.

Available water capacity is high in these soils. Permeability is very slow. The surface layer is medium acid unless it has been limed, and it is high in content of organic matter. The subsoil is very low in available phosphorus and potassium.

These soils are wet in spring and need drainage if they are to be farmed. When adequately drained they are moderately suited to row crops and hay. They are generally farmed along with the adjoining soils.

Representative profile of Tuskeego silt loam, 0 to 2 percent slopes, in a pasture 130 feet north and 1,100 feet east of the SW. corner of sec. 22, T. 77 N., R. 15 W.:

A1—0 to 9 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; moderate, fine, granular structure; very friable; medium acid; clear, smooth boundary.

A21—9 to 13 inches, dark-gray (10YR 4/1) silt loam, light gray (10YR 6/1) when dry; few, fine, faint mottles of very dark grayish brown (10YR 3/2); weak, medium, platy structure that parts to moderate, very fine, subangular blocky; very friable; common roots; medium acid; gradual, smooth boundary.

A22—13 to 21 inches, grayish-brown (10YR 5/2) light silty clay loam; common, medium, faint mottles of dark yellowish brown (10YR 4/4); moderate, fine, subangular blocky structure; friable; few roots; medium acid; clear, smooth boundary.

B1g—21 to 27 inches, dark-gray (10YR 4/1) silty clay loam; few, fine, prominent mottles of dark brown (7.5YR 3/2); weak, medium, prismatic structure that parts to moderate, fine, subangular blocky; friable; many gray silt coatings on ped faces; few roots; medium acid; clear, smooth boundary.

B21tg—27 to 34 inches, very dark gray (10YR 3/1) light silty clay; common, fine, prominent mottles of strong brown (7.5YR 5/8); moderate, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; thick, discontinuous clay films; few roots; neutral; gradual, smooth boundary.

B22tg—34 to 48 inches, olive-gray (5Y 5/2) light silty clay; common, medium, prominent mottles of strong brown (7.5 5/6); moderate, medium, prismatic structure that parts to moderate, medium, subangular blocky; firm; thick, discontinuous clay films; few roots to a depth of 36 inches; few soft black oxides; neutral; gradual, smooth boundary.

B3tg— 48 to 67 inches, gray (10YR 5/1) heavy silty clay loam; common, medium, prominent mottles of dark brown (7.5YR 4/4); weak, medium, subangular blocky structure; firm; thick, discontinuous clay films; neutral; diffuse, smooth boundary.

Cg—67 to 90 inches, light-gray (10YR 6/1) silty clay loam; common, medium, prominent mottles of strong brown (7.5YR 5/6); weak, coarse, subangular blocky structure to massive; firm; neutral.

The A1 or Ap horizon ranges from 6 to 10 inches in thickness. It is very dark gray (10YR 3/1) or very grayish brown (10YR 3/2). The A2 horizon is dark gray (10YR 4/1) to grayish brown (10YR 5/2). Depth to the B horizon is typically about 21 inches but ranges from 17 to 24 inches. Clay films in the B horizon range from thin to thick and are discontinuous. Depth to the C horizon ranges from 55 to 72 inches.

Tuskeego soils are associated with Humeston, Vesser, and Zook soils. They have a thinner A1 horizon and are higher in content of clay in the B2 horizon than Vesser soils. Tuskeego soils lack the dark organic coatings in the upper part of the B horizon of Humeston soils. They have a much thinner A1 horizon than Zook soils, and unlike Zook soils, Tuskeege soils have an A2 horizon.

Tuskeego silt loam, 0 to 2 percent slopes (453).—This soil is in nearly flat or slightly depressional areas on bottom land. The areas are irregular in shape and are generally 10 to 30 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping is similar soil that has slightly less clay in the subsoil. Also included are small areas of Vesser, Zook, Radford, and Humeston soils.

Runoff is very slow on this soil, and in places water ponds on the surface, especially in wet periods. This soil becomes saturated in spring, unless drainage is provided. The surface layer is friable. Under proper moisture conditions tilth is good and the soil is easy to till.

This soil is moderately well suited to corn, soybeans, and hay where adequate drainage is provided. Capability unit IIIw-2; woodland suitability group 5w3.

Vesser Series

The Vesser series consists of deep, somewhat poorly drained to poorly drained soils that formed in silty alluvium. These nearly level soils are on low foot slopes and benches near the larger streams in the county. Slopes are 0 to 5 percent. The native vegetation was grasses and trees that tolerate excessive wetness.

In a representative profile the surface layer is very dark grayish-brown and very dark gray silt loam 17 inches thick. The subsurface layer is dark-gray silt loam that extends to a depth of 33 inches. It is distinctly light colored when dry. The subsoil is dark gray to a depth of 68 inches. It is silty clay loam in the upper 17 inches, silty clay in the middle 18 inches, and light-gray heavy silty clay loam in the lower 12 inches. Common or many yellowish-brown mottles are below a depth of about 45 inches. The substratum is similar to the lower part of the subsoil in color and in content of clay.

Available water capacity is high in these soils. Permeability is moderately slow. The surface layer is high in content of organic matter. The subsoil is medium in available phosphorus and low in available potassium. Vesser soils need to be protected from overwash and flooding caused by

runoff from adjacent higher lying soils. They require supplemental drainage.

These soils are used intensively for row crops and are moderately well suited to corn and soybeans.

Representative profile of Vesser silt loam, 0 to 2 percent slopes, in a meadow 1,000 feet west and 1,200 feet south of the NE. corner of SW¼ sec. 29 T. 76 N., R. 14 W.:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam; very dark gray (10YR 3/1) coatings on ped faces; weak, fine, platy structure that parts to moderate, fine, granular; friable; few roots; in places plow layer includes recent overwash; neutral; clear, smooth boundary.

A12—9 to 17 inches, very dark gray (10YR 3/1) silt loam; weak, fine, platy structure that parts to moderate, medium and fine, granular; friable; few roots; medium acid; clear, smooth boundary.

A21—17 to 28 inches, dark-gray (10YR 4/1) silt loam, light gray (10YR 6/1) when dry; weak, fine, platy structure that parts to weak, very fine, granular; friable; few roots; medium acid; gradual, smooth boundary.

A22—28 to 33 inches, dark-gray (10YR 4/1) heavy silt loam, light gray (10YR 6/1) when dry; weak, fine, platy structure that parts to moderate, fine, granular; friable; medium acid; gradual, smooth boundary.

B21tg—33 to 44 inches, dark-gray (10YR 4/1) medium silty clay loam; very dark gray (10YR 3/1) coatings on ped faces; medium, fine, subangular blocky structure; friable; common, thick, discontinuous clay films of black (10YR 2/1); medium acid; clear, smooth boundary.

B22tg—44 to 50 inches, dark-gray (10YR 4/1) heavy silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/4); moderate, medium, subangular blocky structure; firm; common, thick, discontinuous clay films of very dark gray (10YR 3/1); medium acid; gradual, smooth boundary.

B23tg—50 to 68 inches, mixed dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) light silty clay; common, fine, distinct mottles of yellowish brown (10YR 5/4); moderate, medium, subangular blocky structure; firm; common clay flows and clay balls of very dark gray (10YR 3/1); thick, discontinuous clay films; medium acid; gradual, smooth boundary.

B3tg—68 to 80 inches, light-gray (5Y 6/1) heavy silty clay loam; many, medium, prominent mottles of yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; firm; thin, discontinuous clay films; many fine tubular pores; medium acid; gradual, smooth boundary.

C—80 to 90 inches, light-gray (5Y 6/1) medium silty clay loam; many, medium, prominent mottles of yellowish brown (10YR 5/6); massive; friable; common black (10YR 2/1) oxides; medium acid.

The A1 horizon ranges from 12 to 18 inches in thickness. It ranges from black (10YR 2/1) or very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). The A2 horizon ranges from 16 to 20 inches in thickness and is dark gray (10YR 4/1) to grayish brown (10YR 5/2). The B2tg horizon is 20 to 36 inches thick and is dark gray (10YR 4/1), dark grayish brown (10YR 4/2), or grayish brown (10YR 5/2). Content of clay in the upper part of the B2tg horizon ranges from 27 to 35 percent, but in places it is as much as 40 percent below a depth of 40 inches. Discontinuous clay films and fills of black (10YR 2/1) to very dark gray (10YR 3/1) are evident in the B horizon. Yellowish-brown (10YR 5/4 to 5/8) to brownish-yellow (10YR 6/6 to 6/8) mottles are also evident in this horizon.

Vesser soils are associated with Amana, Humeston, and Tuskeego soils. They have a thicker A2 horizon and less clay in the B2t horizon than Humeston and Tuskeego soils. Vesser soils also are lighter in color in the upper part of the B2t horizon than Humeston soils. Vesser soils, unlike Amana soils, have a thick A2 horizon and content of clay in the B2t horizon is noticeable more than that in the A2 horizon.

Vesser silt loam, 0 to 2 percent slopes (51).—This soil is on low stream terraces along the Des Moines and Skunk Rivers and their major tributaries. Areas of this soil are various shapes and sizes. They commonly range from 10 to 40 acres.

This soil has the profile described as representative for the Vesser series. Some areas that are protected from overwash have a black surface layer. Also a few areas have as much as 18 inches of very dark grayish-brown silt loam overwash.

Included with this soil in mapping are small areas of Humeston, Amana, Colo, and Zook soils.

Runoff is slow on this soil. The major limitation of this soil is wetness. Some areas are in slight depressions, and in many of these areas water ponds on the surface after heavy rains or stream overflow. Tilth is generally good except where water stands.

This soil, if adequately drained, is well suited to corn and soybeans. Capability unit IIw-2; woodland suitability group 5w3.

Vesser silt loam, 2 to 5 percent slopes (51B).—This soil is on foot slopes along the outer edge of valleys and low benches. Areas are above soils in the first bottoms of the larger streams in the county. They are various shapes and sizes but are commonly 5 to 30 acres in size.

This soil has a profile similar to the one described as representative for the Vesser series, but in places the overwash in this soil is silt loam that has high content of sand.

Included with this soil in mapping are small areas of Judson, Ely, and Olmitz soils on foot slopes.

Runoff is slow to medium on this soil. The hazard of erosion is slight. This soil is friable and easily tilled. It is wet and seepy in wet years and requires tile drainage. Also, it needs protection against runoff water and material from adjacent slopes at higher elevation. This soil is generally farmed along with the adjacent soils on bottom land or terraces.

This soil is well suited to corn and soybeans. Capability unit IIw-3; woodland suitability group 5w3.

Watkins Series

The Watkins series consists of deep, well drained to moderately well drained soils that formed in silty alluvium. These soils are on low benches or high second bottoms. They are generally higher than the maximum height of flood water. Slopes are 0 to 5 percent. The native vegetation is a mixture of grass and trees.

In a representative profile the surface layer is very dark brown silt loam 8 inches thick. The subsurface layer is dark grayish-brown silt loam that extends to a depth of 14 inches. The subsoil extends to a depth of 55 inches. It is brown heavy silt loam to light silty clay loam in the upper part, brown silty clay loam in the middle, and brown silty clay loam in the lower part. A few mottles of olive gray and yellowish brown are in the lower part. The underlying material, between depths of 55 and 80 inches, is brown silty clay loam. Below this is brown clay loam.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is slightly acid and is moderate in content of organic matter. The subsoil is low in available phosphorus and very low in available potassium.

Watkins soils can be cultivated intensively to row crops, but individual areas are generally so small that they are managed along with the adjacent soils.

Representative profile of Watkins silt loam, 0 to 2 percent slopes, in a cultivated area about 300 feet west and 250 feet south of the NE. corner of NE¼SE¼ sec. 18 T. 75 N., R. 17 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—8 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, medium, platy structure that parts to weak, fine, subangular blocky; friable; slightly acid; clear, smooth boundary.
B1—14 to 18 inches, brown (10YR 4/3) heavy silt loam; very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) coatings on ped faces; moderate, medium, subangular blocky structure; friable; continuous silt coatings of light brownish gray (10YR 6/2) on ped faces; dry; medium acid; clear, smooth boundary.
B21t—18 to 30 inches, brown (10YR 4/3) light silty clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; moderate, medium, subangular blocky structure; friable; thin, discontinuous clay films; common light brownish-gray (10YR 6/2) silt coatings; common roots; medium acid; gradual, smooth boundary.
B22t—30 to 40 inches, brown (10YR 4/3) silty clay loam; high in content of sand; dark grayish-brown (10YR 4/2) coatings on ped faces; moderate, medium, subangular blocky structure; firm; thin, discontinuous clay films; few roots; strongly acid; gradual, smooth boundary.
B3t—40 to 55 inches, brown (10YR 4/3) silty clay loam; high in content of sand; few, medium, distinct olive-gray (5Y 5/2) and yellowish-brown (10YR 5/6) mottles; compound of moderate, coarse, prismatic structure and weak, coarse, subangular blocky; friable; thin, discontinuous clay films on vertical ped faces; strongly acid; diffuse, smooth boundary.
C1—55 to 80 inches, brown (10YR 4/3) silty clay loam; high in content of sand; weak, coarse, subangular blocky structure; friable; some vertical cleavage; common tubular pores; medium acid; diffuse, smooth boundary.
C2—80 to 96 inches, brown (10YR 5/3) clay loam; massive; firm; medium acid.

The A1 horizon ranges from 6 to 9 inches in thickness. It ranges in color from very dark brown (10YR 2/2) to very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The A2 horizon ranges from 4 to 8 inches in thickness. It is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2). The B1 horizon is heavy silt loam or light silty clay loam. The B2t horizon is typically light silty clay loam but ranges to medium silty clay loam. Above a depth of 40 inches the soil may feel gritty because of the content of fine and medium sand, but it is less than 15 percent sand. Watkins soils show evidence of stratification in places by having lenses of sandy material at depths below 40 inches. The average content of clay in the upper 20 inches of the B horizon is about 30 to 32 percent. Depth to the C horizon ranges from 36 to 60 inches.

Watkins soils are associated with Downs, Fayette, Huntsville, Judson, and Wiota soils. They have a thinner A1 horizon than Wiota, Huntsville, or Judson soils. Watkins soils formed in alluvium, and Fayette and Downs soils formed in loess. The evidence of stratification below a depth of 40 inches in Watkins soils is not present in Fayette and Downs soils.

Watkins silt loam, 0 to 2 percent slopes (687).—This soil is on low benches or high second bottoms. It is in the valleys of the larger streams and rivers. Areas of this soil are generally 5 to 20 acres in size.

This soil has the profile described as representative for the Watkins series. In places the content of clay in the subsoil is slightly lower than that of the representative soil.

Included with this soil in mapping are areas as much as 10 acres in size of a similar soil that is somewhat poorly drained, has a grayer subsoil, and also has more mottles in the subsoil. It makes up as much as 40 percent of some areas.

Runoff is slow to medium on this soil. The surface layer is friable and easy to till. Tilth is good.

This soil can be intensively cultivated. It is well suited to corn, soybeans, and hay. Capability unit I-1; woodland suitability group 1o1.

Watkins silt loam, 2 to 5 percent slopes (687B).—This soil is on low benches or high second bottoms. It is in the valleys of the larger streams and rivers. Areas of this soil are generally 5 to 20 acres in size.

This soil has a profile similar to that described as representative for the series, but the surface layer is thinner.

Included with this soil in mapping are areas as much as 10 acres in size of a similar soil that is somewhat poorly drained, has a grayer subsoil, and has more mottles. It makes up as much as 40 percent of some areas.

Runoff is medium on this soil. The hazard of erosion is slight during hard rains. The surface layer is friable and easy to till. Tilth is good.

This soil can be cultivated intensively. It is well suited to corn, soybeans, and hay. Capability unit IIe-1; woodland suitability group 1o1.

Weller Series

The Weller series consists of deep, moderately well drained soils that formed in loess. These soils are on convex ridge crests and valley side slopes in uplands in the southwestern part of the county. Slopes are 5 to 9 percent. The native vegetation was trees.

In a representative profile the surface layer is very dark grayish-brown silt loam 5 inches thick. The subsurface layer is brown silt loam about 4 inches thick. The subsoil generally extends to a depth of more than 60 inches. The upper part is brown silty clay loam that has gray silt coatings on ped faces. The middle, between depths of 20 and 28 inches, is mottled, yellowish-brown and grayish-brown light silty clay that has gray silt coatings and clay films on ped faces. The lower part, to a depth of 54 inches, is mainly grayish-brown silty clay loam that has mottles of strong brown. Dark clay and organic coatings are on prism faces between depths of 44 and 54 inches.

Available water capacity is high in these soils. Permeability is slow. The surface layer is generally medium acid unless it has been limed, and it is low in content of organic matter. The subsoil is medium in available phosphorus and very low in available potassium.

Weller soils are subject to erosion. Where they are properly managed they are suited to row crops and hay.

Representative profile of Weller silt loam, 5 to 9 percent slopes, moderately eroded, in a cultivated area 790 feet north and 100 feet east of the SW. corner of NW¼ sec. 30, T. 74 N., R. 17 W.:

Ap—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) when dry; weak, fine, granular structure; friable; medium acid; abrupt, smooth boundary.
A2—5 to 9 inches, brown (10YR 4/3) silt loam, light brownish gray (10YR 6/2) when dry; weak, medium, platy structure that parts to weak, fine, granular; friable; slightly acid; clear, smooth boundary.
B1—9 to 14 inches, brown (10YR 4/3) silty clay loam; moderate, medium, subangular blocky structure; friable; many gray silt coatings on ped faces; strongly acid; clear, smooth boundary.
B21t—14 to 20 inches, brown (10YR 4/3) heavy silty clay loam; few, fine, distinct mottles of grayish brown (2.5Y 5/2); strong, fine, blocky structure; friable; many gray silt coatings on ped faces; thin, continuous clay films; strongly acid; clear, smooth boundary.
B22t—20 to 28 inches, mottled, yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) light silty clay; weak, medium, prismatic structure that parts to strong, fine, blocky; firm; common gray silt coatings; thin, discontinuous clay films; common iron and manganese concretions; medium acid; clear, smooth boundary.
B23t—28 to 34 inches, mottled, yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) heavy silty clay loam; many, fine, distinct mottles of strong brown (7.5YR 5/6 and

5/8); weak, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; thin, discontinuous clay films; few manganese concretions; medium acid; clear, smooth boundary.

B31—34 to 44 inches, grayish-brown (2.5Y 5/2) silty clay loam; few, medium, prominent mottles of strong brown (7.5YR 5/6 and 5/8); weak, medium, prismatic structure that parts to weak, medium, subangular blocky; friable; common manganese concretions; medium acid; gradual, smooth boundary.

B32—44 to 54 inches, grayish-brown (2.5Y 5/2) light silty clay loam; few, medium, prominent mottles of strong brown (7.5YR 5/6 and 5/8); weak, medium, prismatic structure that parts to weak, medium and coarse, subangular blocky; friable; dark clay and organic coatings on prism faces; medium acid.

The A1 horizon ranges from 4 to 6 inches in thickness. It is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2). The A2 horizon ranges from 3 to 7 inches in thickness. It is dark grayish brown (10YR 4/2) to brown (10YR 5/3). The maximum content of clay in the B2t horizon is 42 to 46 percent. Depth to the C horizon ranges from 54 to 74 inches.

Weller soils are associated with Clinton and Pershing soils. They have a thinner A1 horizon than Pershing soils. Weller soils are higher in content of clay in the B horizon than Clinton soils.

Weller silt loam, 5 to 9 percent slopes, moderately eroded (132C2).—This soil is on convex ridges and side slopes surrounding the more gently sloping upland divides. The areas are generally rather long and narrow, have irregular boundaries, and are 10 to 20 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of Pershing and Clinton soils.

Runoff is medium on this soil. The hazards of soil blowing and water erosion are moderate where the surface is not protected by good management practices.

This soil is used mainly for pasture and hay. It is moderately suited to corn or soybeans if erosion is controlled. Capability unit IIIe-3; woodland suitability group 4w1.

Wiota Series

The Wiota series consists of deep, moderately well drained and well drained soils that formed in silty alluvium. These soils are on low benches and on second bottom lands. Slopes are less than 2 percent. The native vegetation was grass.

In a representative profile the surface layer is very dark brown and dark brown silt loam 24 inches thick. The subsoil extends to a depth of 64 inches. It is dark-brown and brown light silty clay loam in the upper part. The middle is brown silty clay loam that has mottles of strong brown and grayish brown and has thin clay films on ped faces. The lower part is mottled, light yellowish-brown and grayish-brown heavy silty clay loam. The underlying material is grayish-brown heavy silty clay loam that has mottles of dark brown and common sand grains and small pebbles.

Available water capacity is high in these soils. Permeability is moderate. The surface layer is high in content of organic matter. The subsoil is very low in available phosphorus and low in available potassium.

These soils are used intensively for and are well suited to row crops.

Representative profile of Wiota silt loam, 0 to 2 percent slopes, in a cultivated area 600 feet north and 150 feet west of the SE. corner of NE¼NE¼ sec. 35, T. 75 N., R. 17 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) when dry; weak, fine, granular structure; friable; neutral, clear, smooth boundary.

A12—8 to 20 inches, very dark brown (10YR 2/2) heavy silt loam; weak, medium, subangular blocky structure that parts to weak, fine, granular; friable; medium acid; clear, smooth boundary.

A3—20 to 24 inches, dark-brown (10YR 3/3) heavy silt loam; very dark brown (10YR 2/2) coatings on ped faces; weak, medium, subangular blocky structure that parts to weak, fine, granular; friable; medium acid; clear, smooth boundary.

B1—24 to 29 inches, dark-brown (10YR 3/3) light silty clay loam; very dark grayish-brown (10YR 3/2) coatings on ped faces; moderate, fine and medium, subangular blocky structure; friable; few fine sand grains; medium acid; clear, smooth boundary.

B21t—29 to 35 inches, brown (10YR 4/3) light silty clay loam; moderate, medium and fine, subangular blocky structure; friable; thin, discontinuous clay films; few fine sand grains; medium acid; gradual, smooth boundary.

B22t—35 to 48 inches, brown (10YR 5/3) silty clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/6) and grayish brown (2.5Y 5/2); moderate, medium and fine, subangular blocky structure; friable; thin, continuous clay films; few, soft, dark oxides; medium acid; gradual, smooth boundary.

B3—48 to 64 inches, mottled light yellowish-brown (10YR 6/4) and grayish-brown (2.5Y 5/2) heavy silty clay loam; weak, medium, subangular blocky structure; firm; few, soft, dark oxides; medium acid; gradual, smooth boundary.

C—64 to 71 inches, grayish-brown (2.5Y 5/2) heavy silty clay loam; common, fine, prominent mottles of strong brown (7.5YR 4/4); massive; firm; common sand grains and small pebbles; medium acid.

The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2). It is typically silt loam but is light silty clay loam in places. The B1 horizon is dark brown (10YR 3/3) or brown (10YR 4/3). The upper part of the B horizon is typically light silty clay loam but ranges to medium silty clay loam. Depth to the C horizon ranges from 50 to 70 inches. In places this horizon has strata of fine and medium sand below a depth 60 inches.

Wiota soils are associated with Ely, Judson, and Nevin soils. The upper part of the B horizon in Wiota soils is browner than that of Nevin and Ely soils. Wiota soils have a more distinct accumulation of clay in the B2 horizon than Judson soils.

Wiota silt loam, 0 to 2 percent slopes (7).—This soil is on low benches or second bottom lands. Areas are somewhat parallel to the stream channel. They are generally irregular in shape and 15 to 40 acres or more in size. This soil has the profile described as representative for the Wiota series.

Included with this soil in mapping are small areas of Wiota soil that has slopes of 2 to 5 percent. Also included are small areas of Nevin, Ely, and Kennebec soils.

Runoff is slow or medium in most areas. The surface layer of this soil is friable and easy to till. Tilth is good.

This soil is used intensively for and is well suited to corn, soybeans, and hay. Capability unit I-1; woodland suitability group 1o1.

Zook Series

The Zook series consists of deep, poorly drained soils that formed in clayey alluvium. These soils are on nearly flat flood plains and in drainageways. Slopes are 0 to 5 percent. The native vegetation was grass and sedges that tolerate wetness.

In a representative profile the surface layer is black silty clay loam 21 inches thick. The subsoil extends to a depth of 75 inches. It is very dark gray light silty clay in the upper part and black heavy silty clay loam and dark-gray light silty clay loam in the lower part. The underlying material is light-gray light silty clay loam.

Available water capacity is high in these soils. Permeability is slow. The surface layer is high in content of organic matter. The subsoil is low in available phosphorus and very low in

available potassium. Wetness resulting from overflow and the high water table limits and delays farming operations. Some rather extensive areas of these soils are often at some distance from the river or stream but are at an elevation only slightly higher than that of the stream. Drainage is often difficult in these areas.

Where these soils are artificially drained and protected from flooding, they are moderately well suited to row crops.

Representative profile of Zook silty clay loam, 0 to 2 percent slopes, in a meadow 900 feet west and 40 feet north of the center of sec. 14, T. 74 N., R. 15 W.:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A12—7 to 21 inches, black (N 2/0) medium to heavy silty clay loam; moderate, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—21 to 28 inches, very dark gray (N 3/0) light silty clay; moderate, medium, subangular blocky structure; firm; neutral; clear, smooth boundary.

B22—28 to 48 inches, black (N 2/0) heavy silty clay loam in the upper part and medium silty clay loam in the lower part; moderate, medium, subangular blocky structure; firm; slightly acid; clear, smooth boundary.

B3g—48 to 75 inches, dark-gray (5Y 4/1) light silty clay loam; weak, medium, subangular blocky structure; firm; few, fine, distinct mottles of light olive brown (2.5Y 5/6); neutral; gradual, smooth boundary.

Cg—75 to 86 inches, light-gray (5Y 6/1) light silty clay loam; common, fine, prominent mottles of yellowish brown (10YR 5/8); weak, medium, subangular blocky structure; friable; neutral.

The A horizon ranges from 20 to 40 inches in thickness. It is black (10YR 2/1 or N 2/0). The B2 horizon is black (N 2/0) to very dark gray (10YR 3/1 or 5Y 3/1). Color values of 3 or less extend to a depth of 40 to 50 inches. At a depth below about 20 inches the B2 horizon is heavy silty clay loam to silty clay. The maximum content of clay in the B2 horizon ranges from 38 to 46 percent. Depth to the C horizon ranges from 40 to 60 inches.

Zook soils are associated with Bremer and Colo soils. They contain more clay in the B horizon than Colo soils. Unlike Bremer soils, Zook soils have color values of 3 or less to a depth of 30 inches or more, and they lack distinct horizons. Also, they have no clay films in the B horizon, and mottles are less evident in Zook soils than they are in Bremer soils.

Zook silt loam, overwash, 0 to 2 percent slopes (54+).—This soil is on the bottom lands of the larger streams in the county. Many areas are adjacent to the foot slopes. In these areas small upland drainageways have emptied on the soil, depositing strata of loamy material on the surface. Other areas have a surface layer of sediment that was deposited by flood waters. This soil is in close association with the Colo and Redford soils of the bottom lands. Areas are 10 to 40 acres in size.

The profile of this soil is similar to that described as representative for the Zook series, but 7 to 17 inches of very dark grayish-brown silt loam overwash is on the surface of this soil.

Runoff is slow on this soil. The stratified silty surface layer is more friable and has better tilth than the surface layer of those Zook soils without overwash. Some areas need supplemental surface drainage. Fieldwork is sometimes delayed by excessive wetness. Crops mature more slowly on this soil than on other Zook soils, and harvests are sometimes delayed because of wetness.

This soil is moderately suited to corn and soybeans if adequate drainage is provided. Capability unit IIIw-1; woodland suitability group 5w3.

Zook silty clay loam, 0 to 2 percent slopes (54).—This soil is on the bottom lands of the larger streams in the county. Many areas are adjacent to foot slopes and are oriented somewhat parallel to the stream channel. Areas of this soil are generally elongated, have irregular boundaries, and are 10 to more than 80 acres in size.

The profile of this soil is the one described as representative for the Zook series. Included in mapping are some rather extensive areas of soils in which the black or very dark gray material is only 30 to 36 inches thick. Often, in combination with a very dark gray surface layer, is a subsoil that has common mottles of dark brown or yellowish brown.

Included in places with this soil in mapping are areas where several inches of very dark grayish-brown silty overwash buries the black silty clay loam surface layer. Also included are some areas where the surface layer is silty clay.

Runoff is slow on this soil. Some areas are ponded after a heavy rain. Soil compaction becomes a problem where this soil is worked when it is too wet.

This soil is used intensively for row crops. If adequate drainage is provided, this soil is moderately suited to corn and soybeans. Capability unit IIIw-1; woodland suitability group 5w3.

Zook silty clay loam, 2 to 5 percent slopes (54B).—This soil is along slightly concave drainageways. In some places it is on foot slopes at lower elevation than soils that formed in shale. Along some extended drainageways areas may be as much as 40 acres in size, but they are generally 5 to 15 acres.

This soil has a profile similar to that described as representative for the Zook series, but the black and very dark gray colors in the surface layer and subsoil do not extend to quite so great a depth. This soil is generally dark gray at a depth of about 36 inches. Also, this soil typically has some evidence of overwash: for example, the surface layer or plow layer is generally not quite so black and is slightly lighter in texture than the soil described as typical for the Zook series.

Since areas of this soil are commonly in drainageways, small areas of Judson, Ely, and Olmitz soils on foot slopes along the drainageways are included in mapping. Also included are areas, often several acres in size, where 7 to 17 inches of very dark grayish-brown silt loam to light silty clay loam overwash is present.

Runoff is slow on this soil. This soil generally is wet because of overflow water and a high water table. The drainageways in which this soil occurs have a high concentration of water at times. In most places this soil is farmed along with surrounding soils because the individual areas are generally too narrow to be cropped separately.

This soil is moderately well suited to corn, soybeans, and hay. Capability unit IIIw-1; woodland suitability group 5w3.

Zook silty clay loam, depressional, 0 to 1 percent slopes (248).—This soil is in slightly concave old stream meanders along the bottom lands of the Des Moines and Skunk Rivers. The areas are generally rather long and narrow and 5 to 15 acres in size.

This soil has the profile described as representative for the Zook series, but it is generally deeper to the horizon of maximum clay.

Included with this soil in mapping are some areas that have several inches of silty, very dark grayish-brown overwash. In places the surface layer is very dark gray light silty clay loam. Strata of sand or loamy sand are often at a depth of 45 inches or more in this soil.

Runoff is very slow on this soil. Since water tends to stand in the depressional areas, some of these areas are not cultivated. Where it is farmed along with adjacent better drained

soils, areas of this soil are the first to show damage from standing water. Where this soil is worked when it is too wet, soil compaction becomes a problem.

This soil is poorly suited to corn and soybeans unless adequate surface drainage is provided. Capability unit IIIw-1; woodland suitability group 5w3.

Use and Management of the Soils

The soils of Mahaska County are used mostly for crops and pasture. Corn, soybeans, and alfalfa are the main crops. The trees in the county grow mostly along streams, or they are planted in windbreaks. This section tells how the soils are used for these purposes and also for building roads, farm ponds, and other engineering structures.

Anyone using this information should do so realizing that any practical grouping of soils is subject to change as technology changes or as new information becomes available.

Use of the Soils for Crops and Pasture

In this subsection the effect of soil properties on the growth of crops is first discussed. Then the system of capability grouping used by the Soil Conservation Service is explained, the groups of soils are described, and use and management of them are discussed. A table lists predicted yields of the principal crops grown in the county at high levels of management.

Farmers must know their soils if they are to make a successful plan for controlling erosion, improving the soil, selecting crops, and maintaining good yields. The suitability of a soil for certain plants and the management needed depends on *drainage, permeability, texture, slope, content of organic matter*, and other characteristics given in the soil descriptions.

Drainage is generally indicated by the color and mottling of the subsoil. For example, the Taintor soils have a dominantly gray subsoil, indicating poor drainage, and the Clinton soils have a brownish-colored subsoil, indicating they are moderately well drained. Besides knowing the drainage class, it is important to know how often and for how long the soil is saturated, the permeability of the major horizons, and the capacity of the soil to hold water available for use by most plants.

Permeability is the ability of the soil to transmit air and water. Fine-textured, compact soils, such as the Zook and Clarinda soils, generally have slow or very slow permeability and absorb moisture slowly. Water ponds on the surface or it runs off rapidly, depending on slope. This runoff can cause erosion, especially if the soil is cultivated. Where artificial drainage is needed, it helps farmers to know the permeability of the soils before deciding what kind of drainage system to install.

Texture is the proportion of sand, silt, and clay in a soil. It affects the amount of water the soil can hold, its permeability, and the ease or difficulty with which it can be cultivated and penetrated by plant roots. Texture is considered in determining the kind of drainage system to install and the choice of crops. Fine-textured soils, such as Clarinda soils, do not absorb moisture rapidly and are difficult to work. Coarse soils, such as Sparta soils, do not hold much water available for use by plants. Soils such as the Otley, Judson, and Olmitz soils have about the right amount of sand, silt, and clay and have very favorable soil texture.

Slope affects runoff and determines the need for controlling erosion. The rate of runoff and the hazard of erosion increase as the degree of slope increases. On slopes of more than 2 percent, the soils are subject to erosion where cultivated. Erosion losses are greater where there is no plant cover. The Gara loam, 14 to 18 percent slopes, moderately eroded, is an example of the way slope affects runoff and erosion. Steep slopes limit the use of farm machinery and generally have thinner stands of row crops than the more nearly level slopes.

An adequate supply of *content of organic matter* is needed. Crops on most of the soils in the county respond to applications of fertilizer. The need for fertilizer depends on the kind of soil, past and present management, and the crop that is grown. Additions of lime are generally needed on most soils unless they have been limed within the past 5 years. A few soils, such as those in the Zook series, generally do not need lime. For best results, the amount of lime and the kinds and amounts of fertilizers can be determined by soil tests.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, all kinds of soil are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that

preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or to esthetic purposes. (None in Mahaska County.)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States, but not in Mahaska County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-3 or IIIw-1. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Mahaska County are described and suggestions for the use and management of the soils are given.

CAPABILITY UNIT I-1

This unit consists of nearly level soils of the Givin, Mahaska, Nevin, Watkins, and Wiota series. These soils have a friable, medium-textured or moderately fine textured surface layer and subsoil.

Permeability is moderate or moderately slow in these soils. Content of organic matter is high in Mahaska, Nevin, and Wiota soils and moderate in Watkins and Givin soils. Rooting depth is several feet.

These soils have generally adequate drainage in most years. In wet years tile drains are beneficial, however, and they permit more timely field operations, particularly on Mahaska soils. The Nevin soils are susceptible to some flooding early in spring or in periods when rainfall is unusually high. Flooding in spring, however, is generally before crops are planted.

These soils are easily tilled. The surface layer of Mahaska soils is slightly finer textured than the surface layer of other soils in this unit, and the Mahaska soils are more suitable for fall plowing. Erosion caused by runoff is not a hazard on any of these soils. Soil blowing is not a serious hazard but does occur where the surface is left exposed during dry winters.

The soils in this unit are well suited to row crops. Soybeans are generally alternated with corn in the cropping system. Insects, weeds, and plant diseases are more difficult to control in fields where corn is grown continuously on soils of this unit. Soils that are heavily cropped and that are plowed to the same depth for successive years tend to develop a plowpan or compact layer at plow depth. This layer restricts the movement of air and water. Changing the depth of plowing helps to prevent the formation of a pan.

CAPABILITY UNIT I-2

This unit consists of nearly level soils of the Amana, Huntsville, and Kennebec series. These soils are well drained to somewhat poorly drained. They can be cropped without supplemental drainage.

Permeability is moderate. Content of organic matter is high. Rooting depth is several feet.

These soils are subject to some flooding. The use of dikes to protect these soils from flooding may be feasible, but floods generally occur early in spring before corn is planted and last only a short time.

The soils in this unit are well suited to row crops. Some areas are in pasture. Although corn is the more important crop, soybeans are generally substituted for it, particularly if the planting of corn is delayed by flooding. Planting corn year after year increases the hazards of plant diseases and insect damage. Controlling weeds is especially important because floodwaters commonly deposit the seeds of these undesirable plants. The soils in this unit are not subject to erosion, and they are often plowed in fall so that planting can be earlier in spring.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping soils of the Clinton, Downs, Fayette, Hedrick, Ladoga, Mahaska, Nira, Otley, and Watkins series. All of these soils are well drained or moderately well drained except for the somewhat poorly drained Mahaska soils. They have a friable, medium-textured or moderately fine textured surface layer and a friable or firm, medium-textured or moderately fine textured subsoil.

Permeability is moderate in the Downs, Fayette, and Watkins soils and moderately slow in the other soils. Content of organic matter is low in Clinton and Fayette soils and moderate or high in the other soils of this unit. Rooting depth is several feet. Runoff generally causes some erosion.

These soils are suited to all crops that are commonly grown in the county (fig. 21). In terraced areas, row crops can be intensively grown without excessive loss of soil. Adequate fertilizer and lime and good weed control are needed for optimum crop growth. Where these soils have been row cropped for several years, returning all crop residues to the soil and applying liberal amounts of manure help to maintain good tilth.

CAPABILITY UNIT IIe-2

This unit consists of gently sloping soils of the Ely, Judson, and Olmitz series. These soils are well drained to somewhat poorly drained and have a friable, medium-textured and moderately fine textured surface layer and subsoil.

Permeability is moderate or moderately slow. Content of organic matter is high. Rooting depth is several feet.

Because the soils in this unit are at the base of upland slopes, the runoff, which does not last long, is likely to damage the soils through sheet erosion and gullying. Runoff and wetness are reduced by placing diversion terraces at the base of upland slopes. Drainage is normally adequate on these soils, but the Ely soil is seasonally wet and benefits from tile drainage.

Figure 21.—**Harvesting corn for silage on Ladoga silt loam, 2 to 5 percent slopes. This soil is in capability unit IIe-1.**

Where the soils in this unit are protected from erosion, they are suited to row crops. Corn and soybeans are the main crops. Not all areas, however, are large enough to crop separately, and the cropping system may be determined by the surrounding soils. Adequate fertilizer and lime and good weed control are needed for optimum crop growth. Where these soils are cropped intensively, returning all crop residues to the soil and applying liberal amounts of manure help to maintain good tilth.

CAPABILITY UNIT IIe-3

This unit consists of gently sloping soils of the Grundy and Pershing series. These soils are somewhat poorly drained to moderately well drained. They have a moderately fine textured or medium-textured surface layer and a fine textured or moderately fine textured subsoil.

Permeability of the subsoil is slow in soils of this unit. Content of organic matter is high. Much of the rainfall is absorbed and is held available for plants. Available water capacity is high.

The soils in this unit are well suited to cultivated crops but are subject to sheet erosion because of slope. Wetness is generally not a problem. Tilth is good.

Most of these soils are used for cultivated crops. Corn and soybeans are the main crops, but oats, hay, or pasture also grow well. If these soils are protected by terraces and tilled on the contour, they are well suited to row crop growth. Eliminating weeds and insects and maintaining tilth is difficult if row crops are grown year after year.

The soils in this unit respond very well to fertilizer. Corn that does not follow a legume in the cropping system generally needs nitrogen. Small grains and legumes respond very well to phosphate and potash. In most places addition of lime is needed.

CAPABILITY UNIT IIw-1

This unit consists of nearly level soils of the Haig and Taintor series. These soils are poorly drained. They have a friable surface layer of silty clay loam and a fine-textured subsoil.

Permeability is moderately slow to very slow in the subsoil. Content of organic matter in the surface layer is high. Rooting depth is several feet. Runoff is slow, and in places water ponds on the surface after heavy rains.

These soils are slow to dry out in spring, and they puddle readily if worked when wet. Tile drainage is generally satisfactory where the spacing and depth of the tile are suitable. In drained areas field operations can be much more timely. Because the water table is at or near the surface in spring and then recedes, plowing often is done in the fall to ensure earlier planting in spring.

These soils are well suited to row crops. Corn and soybeans are the main crops. Erosion is not a hazard. Soil blowing is not a serious hazard but does occur in dry winters where the surface is left exposed in large fields.

CAPABILITY UNIT IIw-2

This unit consists of nearly level soils of the Bremer, Colo, Ossian, and Vesser series. The Bremer and Colo soils are poorly drained and have a moderately fine textured or medium textured surface layer and a moderately, fine textured subsoil. The Ossian and Vesser soils are somewhat poorly drained or poorly drained. They have a medium-textured surface layer.

Permeability is moderately slow to slow in the Bremer and Colo soils and moderate in the Ossian and Vesser soils. Content of organic matter is high in all the soils of this unit. Rooting depth is several feet.

These soils have a seasonally high water table and are subject to flooding. Flooding commonly occurs early in spring, and most floods are of short duration. Recent floodwaters have deposited a lighter colored and coarser textured material on some areas of the Colo soils. In some places siltation is a hazard if heavy rains occur when crops are small and adjoining soils at higher elevations have not been protected from erosion. Artificial drainage is generally required for maximum crop growth, and tile drainage is successful where suitable outlets are available. In addition, surface drainage is needed in depressional areas that collect surface water.

If the soils in this unit are adequately drained and well managed, they are well suited to row crops (fig. 22). Corn is the most important crop, but soybeans are often substituted for it in the cropping system. These soils are commonly plowed in fall. Crops generally can be planted in spring if plowing is done during the previous fall at the time when moisture content is more favorable.

CAPABILITY UNIT IIw-3

This unit consists of gently sloping soils of the Colo, Ely, Nodaway, and Vesser series. These soils are moderately well drained, somewhat poorly drained, or poorly drained. The Nodaway and Vesser soils have a friable, medium-textured surface layer. The Colo and Ely soils are moderately fine textured.

Permeability is moderately slow in Colo soils and moderate in the other soils in this unit. Content of organic matter is low to moderate in the Nodaway soils and high in the other soils in this unit. Rooting depth is several feet.

The soils of this unit are wet mainly because of a seasonally high water table and seepage from the higher soils on uplands. Flooding by runoff is common for short periods. Gullying is

Figure 22.—**Colo silty clay loam (capability unit IIw-2) and Zook silty clay loam on nearly level bottom lands used for row crops. Sandy Chelsea soils are on uplands in background.**

likely to occur where runoff water concentrates. Siltation is also a hazard if heavy rains occur when plants are young and adjoining soils at higher elevations are not protected from erosion.

Permanent grassed waterways are needed on these soils where the water concentrates and gullies tend to form. In places additional erosion-control structures are needed to prevent gullies from forming at tile outlets. Tile lines are beneficial if they are properly installed. A tile line on each side of the water course is commonly needed to lower the water table and to control seepage.

Although the soils in this unit are well suited to row crops, areas are small or of odd shape in some places, and the cropping system is determined by the surrounding cultivated soils. In many places, however, these areas are so located that it is difficult to fertilize them separately from the rest of the field. Because the soils of this unit are generally higher in fertility than adjoining soils, it is better to keep samples of adjoining soils on uplands separate from samples of soils in this unit when making soil tests.

CAPABILITY UNIT IIw-4

Landes fine sandy loam, 0 to 2 percent slopes, is the only soil in this unit. This soil is well drained and has a moderately coarse textured surface layer and subsoil.

Permeability is moderately rapid or rapid. Content of organic matter is moderate. Rooting depth is several feet.

This soil has a seasonally high water table and is subject to overflow in spring. In dry winters soil blowing is a hazard on this soil where the surface is left exposed.

This soil is suited to hay, pasture, or row crops. Adequate fertilizer is needed. Leaving crop residues on the surface or working them part way into the soil in areas that are row cropped helps to maintain good tilth. Applying liberal applications of manure is needed to help maintain good tilth where crop residues are removed from intensively farmed areas.

CAPABILITY UNIT IIw-5

This unit consists of nearly level soils of the Nodaway, Radford, and Spillville series. These soils are somewhat poorly drained and moderately well drained. They have a friable, medium-textured surface layer. The soils are mainly medium textured above a depth of 60 inches. The Radford soils typically are moderately fine textured below a depth of about 30 inches, however, and the Spillville soil that has a sandy substratum has fine sand at a depth of about 40 to 50 inches.

Permeability is moderate. Content of organic matter is low or moderate in Nodaway soils and high in Radford and Spillville soils. Rooting depth is several feet.

Figure 23.—**Pasture of Ladoga silt loam (foreground) and Clinton silt loam (background).**

Water that overflows on these soils generally causes more damage by siltation than by erosion. These soils have a seasonally high water table in spring. Wetness is generally of short duration but sometimes delays farming operations.

These soils are suited to all crops that are commonly grown in the county. They can be intensively planted to row crops but generally require protection from overflow for optimum crop growth. Adequate fertilizer and lime and good weed control are also needed. Good tilth can be maintained on these soils where they are cropped intensively if all crop residues are returned to the soil or liberal amounts of manure are applied.

CAPABILITY UNIT IIIe-1

This unit consists of moderately sloping soils of the Clinton, Fayette, Hedrick, Judson, Ladoga, Nira, Olmitz, and Otley series. These soils are moderately well drained and well drained. They have a friable, medium-textured or moderately fine textured surface layer and subsoil.

Permeability is moderate or moderately slow. Content of organic matter is low in Clinton, Hedrick, and Fayette soils; high in Judson soils; and moderate in Ladoga, Otley, and Nira soils. Rooting depth is several feet. These soils are subject to erosion.

These soils are moderately suited to all crops commonly grown in the county (fig. 23). Row crops grow better if they are planted on the contour, stripcropped, or terraced to help control erosion. Adequate fertilizer and lime and good weed control are needed for optimum crop growth. Good tilth can be maintained on these soils where they have been row cropped if all crop residues are returned to the soil or liberal amounts of manure are applied.

CAPABILITY UNIT IIIe-2

This unit consists of strongly sloping soils of the Clinton, Fayette, Ladoga, Hedrick, Otley, and Seaton series. These soils are moderately well drained and well drained. They have a friable, medium-textured or moderately fine textured surface layer and subsoil.

Permeability is moderate or moderately slow. Content of organic matter is low in Fayette, Hedrick, and Seaton soils and moderate in Ladoga and Otley soils. Rooting depth is several feet. This depth is greatly affected by the strong slopes, and runoff from the slopes causes erosion.

These soils are moderately suited to all crops that are commonly grown in the county. If row crops are grown in terraced fields and farmed on the contour, erosion losses can be held to an acceptable level (fig. 24). Adequate fertilizer and lime are needed for optimum crop growth. Returning all crop residue to the soil or applying liberal amounts of manure helps to maintain tilth.

CAPABILITY UNIT IIIe-3

This unit consists of moderately sloping soils of the Grundy, Pershing, and Weller series. These soils are somewhat poorly

drained and moderately well drained. They have a friable, medium-textured or moderately fine textured surface layer and a firm, moderately fine textured subsoil.

Permeability is slow in soils of this unit. Content of organic matter is high in Grundy soils, moderate in Pershing soils, and low in Weller soils. Rooting depth is several feet. Runoff, because of slope, causes some erosion.

These soils are moderately well suited to all crops commonly grown in the county. Where they are eroded and the upper part of the subsoil is mixed into the plow layer, the surface becomes less friable and harder to farm. Contour tillage is the practice used most often to control erosion where row crops are grown. Adequate fertilizer and lime are needed for optimum crop growth. Good tilth is very important on these soils. Returning all crop residue to the soil or applying liberal applications of manure helps to maintain tilth.

CAPABILITY UNIT IIIe-4

This unit consists of moderately sloping soils of the Clarinda and Lamoni series. These soils have a friable or firm, moderately fine textured surface layer and a very firm, fine-textured subsoil that restricts the downward movement of water. These soils are seasonally wet, because water seeps from the more permeable soils upslope.

Permeability is slow or very slow. Content of organic matter is low to high. Rooting depth is a few feet. Runoff is fairly rapid, and erosion is difficult to control.

The soils of this unit puddle easily if they are worked when wet, and they dry out cloddy and hard. In spring tractors are often mired in these wet areas. In many places, tile drains are installed upslope from soils of this unit to intercept water. This helps to prevent wetness and seepiness in these soils.

These soils are not well suited to row crops. Where row crops are planted, it is helpful to till the soil on the contour. These soils are difficult to terrace because cuts expose the heavily compacted, infertile subsoil. Although the response to fertilizer is fairly good, crops generally do not grow well. Many areas are left in meadow for an extra year or more where the surrounding soils are cultivated.

CAPABILITY UNIT IIIw-1

This unit consists of nearly level and gently sloping soils of the Zook series. These soils are poorly drained. They have a black, friable, moderately fine textured surface layer and a moderately fine textured or fine-textured subsoil. Some areas of these soils are covered with several inches of recent overwash that consists of stratified sediment.

Permeability is slow in the subsoil. Content of organic matter is high. Rooting depth is a few feet. The water table is seasonally at or near the surface.

These soils warm slowly in spring, and they cannot be worked early in spring or soon after rains. They puddle readily if worked when wet, and they dry out hard and cloddy. If these soils are plowed in fall, freezing and thawing

Figure 24.—**Contour farming on Ladoga silt loam, capability unit IIIe-2.**

in winter improve tilth. Tilth is generally better in soils that have a silt loam overwash than in the other soils. Such soils can be worked through a wider range of moisture content.

Flooding often occurs early in spring before crops are planted, but in some years damage to crops is extensive. In years that have above-average rainfall, many areas are left idle because crops cannot be planted or are drowned out.

Improved areas of the soils in this unit are used for cultivated crops, but use of these soils is generally limited because of wetness and flooding. Corn is the main row crop, but soybeans also are grown.

Adequate fertilizer and good weed control are needed to obtain optimum crop growth. Adequate or good tilth can generally be maintained if all crop residues are returned to the soil or if liberal applications of manure are applied. Properly spaced tile lines lower the water table in these soils. Shallow surface drains are helpful in removing surface water.

CAPABILITY UNIT IIIw-2

This unit consists of nearly level soils of the Humeston, Rubio, Sperry, and Tuskeego series. These soils are poorly or very poorly drained. They have a friable, medium-textured surface layer and subsurface layer and a firm, fine-textured subsoil. They are generally in slightly depressional areas and are often ponded during extended wet periods or after heavy rains. The Humeston and Tuskeego soils are occasionally flooded.

Permeability is slow or very slow in the subsoil. Content of organic matter is moderate or high.

Corn and soybeans are the principal crops, but the cropping system is generally determined by the way in which surrounding soils are used. Alfalfa and other legumes are frequently drowned or winterkilled.

In many places the soils of this unit are in small areas, and in wet years these areas may be left idle and only the surrounding soils cultivated. Tile lines do not drain in all areas satisfactorily, and surface drains are needed. Crop response to fertilizer varies, but it is good in years of average rainfall and in adequately drained areas. Although the soils in this unit require fertilizer, they are generally in areas of such size and shape that they are fertilized in the same way as the larger areas of surrounding soils. Consequently, care should be taken not to include samples of soils in this unit when samples for soil tests are being taken for the surrounding soils.

CAPABILITY UNIT IIIw-3

This unit consists of moderately sloping soils of the Clearfield series. These soils are poorly drained or somewhat poorly drained. They have a friable, moderately fine textured surface layer and subsoil.

Permeability is moderately slow. Content of organic matter is high. Rooting depth is several feet. Runoff because of slope causes erosion in places.

Because these soils are at the seep line, wetness in spring sometimes delays farming operations. Tile drainage is needed.

These soils are moderately well suited to all of the crops commonly grown in the county. Acceptable soil loss can be maintained if row crops are grown in fields that are farmed on the contour. Adequate applications of fertilizer and good weed control are needed for optimum crop growth. Good tilth can be maintained where these soils have been row cropped for several years by returning all crop residues to the soil or by applying liberal amounts of manure.

CAPABILITY UNIT IIIs-1

Flagler fine sandy loam, 0 to 2 percent slopes, is the only soil in this unit. The surface layer and subsoil of this soil are moderately coarse textured. The underlying material is loamy sand to gravelly sand.

Permeability is moderately rapid to rapid in this soil. The content of organic matter is moderate. Many areas of this soil are subject to flooding where stream levels are very high. A high water table sometimes remains after periods of high water. During extended dry periods this soil is quite droughty, and crop growth is frequently lower at these times.

This Flagler soil is moderately well suited to corn and soybeans. It is well suited to hay and pasture. Adequate lime and fertilizer is an important factor in increasing crop growth.

CAPABILITY UNIT IVe-1

This unit consists of moderately eroded and severely eroded, strongly sloping and moderately steep soils of the Clinton, Fayette, Hedrick, and Seaton series. These soils are well drained and moderately well drained. All except the Seaton soils have a friable, medium-textured surface layer and a moderately fine textured subsoil. Seaton soils have a medium-textured subsoil.

Permeability is moderate in Fayette and Seaton soils and moderately slow in Clinton, Hedrick, and Lindley soils. Content of organic matter is low. Rooting depth is several feet. These soils are subject to runoff and erosion.

These soils are poorly suited to row crops and well suited to hay or pasture. Terracing is recommended where these soils are used for crops. These soils are better suited to meadow or hay most of the time than to other uses. Adequate fertilizer and lime are needed for optimum crop growth. All crop residue should be returned to these soils, or liberal amounts of fertilizer should be applied to help maintain tilth.

CAPABILITY UNIT IVe-2

This unit consists of strongly sloping soils of the Armstrong, Clarinda, and Lamoni series. Armstrong soils are moderately well drained or somewhat poorly drained, Clarinda soils are poorly drained, and Lamoni soils are somewhat poorly drained. These soils have a friable, moderately fine textured or medium-textured surface layer and a firm, compact, fine-textured subsoil.

Permeability is slow or very slow. Content of organic matter is low to high. Rooting depth is a few feet. Cultivated areas are susceptible to erosion.

These soils are generally in narrow bands that are almost on contours around the hillside. Many small areas are surrounded by larger areas of soils that are used for row crops, but the small areas often are left in grass when the surrounding areas are cultivated.

Erosion control is difficult in areas that are cropped along with the surrounding soils. Building terraces in these areas exposes the fine-textured, infertile subsoil in the terrace channels. Drainage is restricted in these soils, and they are seasonally wet and seepy. Tiles are placed in soils upslope in many places to intercept water that could cause wetness and seepiness in these soils.

The soils in this unit are suitable for small grains, hay, and pasture. They are poorly suited to row crops. Many areas of these soils are suitable for farm ponds that supply water for livestock. Adequate fertilizer and lime are needed for optimum crop growth. All crop residues need to be returned to the soil and liberal applications of manure in eroded spots should be made to help maintain tilth.

***Figure 25.*—Farm pond on Lindley loam provides water for livestock and recreation.**

CAPABILITY UNIT IVe-3

This unit consists of strongly sloping soils of the Caleb, Gara, Keswick, and Lindley series. These soils are moderately well drained and well drained. They have a friable, medium-textured surface layer and a friable or firm, medium-textured or moderately fine textured subsoil.

Permeability is moderate in Caleb soils, moderately slow in Gara and Lindley soils, and slow in Keswick soils. Content of organic matter is low or very low. Rooting depth is several feet. Runoff is rapid, and erosion is a severe hazard.

Good management is needed to control erosion. Terracing is only moderately satisfactory because the landscape is hilly. Also, the subsoil is firm and has moderately slow or slow permeability in Gara, Lindley, and Keswick soils. In some areas gullies need to be shaped and seeded.

These soils are not well suited to row crops. Because of past erosion tilth is somewhat poor. Also, these soils dry out hard and become cloddy if they are plowed where they are wet. These soils provide suitable sites for farm ponds that supply water for livestock (fig. 25).

CAPABILITY UNIT IVe-4

This unit consists of moderately steep and strongly sloping soils of the Armstrong, Gara, and Shelby series. Armstrong soils are somewhat poorly drained, and Gara and Shelby soils are moderately well drained or well drained. The Armstrong and Gara soils in this unit are mapped in a complex because they are associated on the landscape in such a way that it is not practical to separate them on the soil maps. These soils have a friable, medium-textured surface layer and a firm, moderately fine textured or fine-textured subsoil.

Permeability is slow in Armstrong soils and moderately slow in Gara and Shelby soils. Content of organic matter is low or moderate. Rooting depth is several feet. The slopes (9 to 18 percent) affect absorption of water and the rate and amount of runoff, and they cause erosion.

These soils are poorly suited to row crops and are well suited to hay or pasture. Terracing is suitable on Gara and Shelby soils. The clayey and firm exposed subsoil of Armstrong soils is not very suitable for crop growth. These soils generally remain in meadow or hay most of the time. Adequate fertilizer and, in places, lime are needed for optimum crop growth. All crop residue should be returned to the soil, or liberal amounts of manure should be applied to help maintain tilth.

CAPABILITY UNIT IVe-5

This unit consists of strongly sloping soils of the Chelsea, Clinton, Otley, and Sparta series. Clinton and Otley soils are moderately well drained. They have a friable, medium-textured or moderately fine textured surface layer and a firm, moderately fine textured subsoil. Chelsea and Sparta soils are

excessively drained. They have a loose or very friable, coarse-textured surface layer over loose, coarse-textured material.

Permeability is moderately slow in Clinton and Otley soils and rapid in Chelsea and Sparta soils. Content of organic matter is low or very low in Clinton, Chelsea, and Sparta soils and moderate in Otley soils. Rooting depth is several feet.

The soils in this unit are quick to warm up in spring, and they can be worked soon after rains. Where they are not adequately protected, Clinton and Otley soils are susceptible to serious damage by runoff and erosion, and Chelsea and Sparta soils are subject to soil blowing. These soils are particularly vulnerable to such deterioration late in winter and late in spring. In most areas management is difficult because slopes are complex. Terraces are difficult to construct on sandy soils, but stripcropping is beneficial for erosion control.

The sandy soils in this unit are droughty and are better suited to hay or pasture than to row crops. A vegetative cover on these soils helps to improve tilth, maintain the content of organic matter, and prevent soil blowing. The sandy soils tend to dominate the management of the areas, even though Clinton and Otley soils are better suited to row crop growth.

CAPABILITY UNIT IVs-1

This unit consists of gently sloping and moderately sloping soils of the Otley and Sparta series and moderately sloping soils of the Chelsea and Clinton series. The Clinton and Otley soils are moderately well drained and have a friable, medium-textured or moderately fine textured surface layer and a firm, moderately fine textured subsoil. The Chelsea and Sparta soils are excessively drained and have a loose or very friable, coarse-textured surface layer and a loose, coarse-textured subsoil.

Permeability is moderately slow in Clinton and Otley soils and rapid or very rapid in Chelsea and Sparta soils. Content of organic matter is low or very low in Chelsea, Clinton, and Sparta soils and moderate in Otley soils. Rooting depth is several feet.

The soils of this unit are quick to warm up in spring, and they can be worked soon after rains. These soils are susceptible to water erosion. Where they are left unprotected, the sandier soils are susceptible to both water erosion and soil blowing, particularly in spring. A vegetative cover on Chelsea and Sparta soils helps to improve the tilth, maintain the content of organic matter in the surface layer, and prevent soil blowing. In most areas management is difficult because slopes are complex. Terrace construction is difficult on the sandy soils. They are better suited to stripcropping, if erosion control is needed, than to terracing.

The sandy soils in this unit are droughty and are better suited to hay or other uses than they are to corn and soybeans. They need adequate fertilizer and lime.

CAPABILITY UNIT Vw-1

This unit consists of nearly level soils of the Amana and Nodaway series and Alluvial land. These soils are dissected by old stream channels and are frequently flooded. Alluvial land is sandy and excessively drained or silty and well drained to somewhat poorly drained. Nodaway and Amana soils are moderately well drained or somewhat poorly drained and medium textured or moderately fine textured.

The soils in this unit are not cultivated except in a few isolated areas. Most areas are under a cover of scattered trees and grass. Cultivated fields are irregular in shape because of oxbows and old bayous. Open areas are used for pasture. Alluvial land is less desirable for pasture than the Amana or Nodaway soils because much of the vegetation is willows, shrubs, sedges, and marsh grass. On the other soils, bluegrass grows in good stands in some places. Crops grow moderately well in areas of Amana and Nodaway soils, but some land leveling and flood protection are required before cropping is feasible. Without major reclamation, the soils of this unit are better suited to pasture, trees, or wildlife habitat than to crops.

CAPABILITY UNIT VIe-1

This unit consists of moderately steep soils of the Armstrong, Caleb, Gara, Keswick, and Lindley series. The Caleb, Gara, and Lindley soils are well drained and moderately well drained. They have a friable, medium-textured surface layer and a friable or firm, medium-textured or moderately fine textured subsoil. The Armstrong and Keswick soils are moderately well drained or somewhat poorly drained. They have a firm, moderately fine textured or fine-textured subsoil.

Permeability is moderate in Caleb soils, moderately slow in Gara and Lindley soils, and slow in Armstrong and Keswick soils. Content of organic matter is low or very low in soils of this unit. Rooting depth is several feet. Runoff and erosion are hazards because of the moderately steep slopes (14 to 18 percent).

These soils are not suited to cultivation. They are well suited to pasture, hay, trees, or wildlife habitat. Adequate fertilizer and lime are needed for optimum crop growth. These soils provide good sites for ponds that supply water for livestock.

CAPABILITY UNIT VIe-2

Seaton silt loam, 18 to 25 percent slopes, moderately eroded, is the only soil in this unit. This soil is steep and well drained. It has a friable, medium-textured surface layer and subsoil.

Permeability is moderate in this soil. Content of organic matter is low or very low. Rooting depth is several feet. Runoff and erosion are hazards because of the steep slopes.

These soils are not suited to cultivation. They are well suited to pasture, trees, or wildlife habitat. The soils are so steep that fertilization is difficult, but where it is done plants respond well to the fertilizer and lime. This soil contains so much silt that it is difficult to compact it enough to prevent seepage when ponds are built.

CAPABILITY UNIT VIs-1

This unit consists of strongly sloping and moderately steep soils of the Chelsea and Clinton series. Chelsea soils are excessively drained and have a loose, coarse-textured surface layer and subsoil. Clinton soils are well drained and have a friable, medium-textured surface layer and a firm, moderately fine textured subsoil.

Permeability is rapid in Chelsea soils and moderately slow in Clinton soils. Content of organic matter is low or very low in soils of this unit. Rooting depth is several feet. Chelsea soils are droughty because much of the moisture is lost by deep percolation.

These soils warm up quickly in spring. Where they are not adequately protected, Chelsea soils are susceptible to serious damage by soil blowing. Clinton soils are susceptible to runoff and damage by water erosion. These are the most serious concerns late in winter and early in spring in areas where

vegetative ground cover is limited. In most areas management is difficult because slopes are complex.

These soils are not suited to cultivation. They are suited to pasture or hay. The response of the Chelsea soils to applications of fertilizer depends on the amount and timeliness of rainfall.

CAPABILITY UNIT VIIe-1

This unit consists of steep soils of the Caleb, Gara, and Lindley series. These soils are well drained and moderately well drained. They have a friable, medium-textured surface layer and a friable or firm, medium-textured or moderately fine textured subsoil.

Permeability is moderate in Caleb soils and moderately slow in Gara and Lindley soils. Content of organic matter is low or very low in soils of this unit. Rooting depth is several feet. Runoff from the slopes of 18 to 25 percent causes erosion.

These soils are not suited to cultivation. They are suited to pasture, trees, or wildlife habitat. The soils provide good sites for ponds that supply water for livestock.

CAPABILITY UNIT VIIe-2

This unit consists of strongly sloping, moderately steep, and steep soils of the Gosport series. These soils are moderately well drained. They have a friable, medium-textured surface layer and a firm, fine-textured subsoil. Shale is at a depth of about 30 inches.

Permeability is slow in soils of this unit. Content of organic matter is low or moderate. Rooting depth is about 2 feet. Runoff because of the slope causes erosion.

These soils are not suited to cultivation. They are suited to pasture or wildlife habitat.

CAPABILITY UNIT VIIw-1

Only the land type Marsh is in this unit. Areas of this land type are covered by water most of the time and have little value except for wildlife habitat. Waterfowl, muskrats, and upland game animals find food and nesting places in and around areas of Marsh. These areas can be improved as habitat for wildlife where controls for a more constant water level are feasible.

Areas of Marsh are suitable for some types of recreation. They also provide income for muskrat trappers and for owners of Marsh who charge for hunting privileges.

CAPABILITY UNIT VIIs-1

This unit consists of shallow, steep and very steep, soils of the Boone and Sogn series. These soils are excessively drained or somewhat excessively drained. The Boone soils have a very friable, moderately coarse textured surface layer. It is underlain by interbedded sand and sandstone. The Sogn soils have a friable, medium-textured surface layer that is underlain by limestone.

Permeability is very rapid in Boone soils and moderate in Sogn soils. Content of organic matter is low. Rooting depth is restricted, and few roots penetrate below a depth of 1 foot. The steep slopes cause runoff and erosion.

These soils are not suited to cultivation. They are suited to pasture, trees, or wildlife habitat. Grazing should be restricted on these soils so that a vegetative cover will be maintained to protect them from erosion.

CAPABILITY UNIT VIIs-2

Only Chelsea loamy fine sand, 18 to 25 percent slopes, moderately eroded, is in this unit. This soil is excessively drained and has a loose, coarse-textured surface layer and subsoil.

Permeability is rapid in this soil. Content of organic matter is very low. Rooting depth is several feet. The soil is droughty because much of the moisture is lost by deep percolation.

This soil warms up early in spring. Where it is not adequately protected by a vegetative cover, it is susceptible to soil blowing.

This soil is not suited to cultivation. It is suited to pasture, trees, or wildlife habitat. Grazing should be limited on this soil so that an adequate vegetative cover will be provided to protect it from erosion.

CAPABILITY UNIT VIIs-3

Only the land type Riverwash is in this unit. Areas of this land type are sandy, rather narrow, and nearly level to gently sloping. They are along the edges of the larger streams in the county. Riverwash is coarse textured throughout and has a high water table.

Permeability is rapid or very rapid. Content of organic matter and natural fertility are very low.

Riverwash is of little value except as a source of sand or gravel. Its usefulness to wildlife is very limited because of a lack of vegetative cover.

Predicted yields

In table 2 the average yields per acre of the principal crops are predicted for soils of the county under a high level of management. Under this level of management, seedbed preparation, planting, and tillage practices provide for adequate stands of suitable varieties; erosion is controlled; the content of organic matter and soil tilth are maintained; the level of fertility for each crop is maintained, as indicated by soil tests and field trials the water level in wet soils is controlled; excellent weed and pest control are provided; and operations are timely.

Many available sources of yield information were used to make these estimates, including data from the federal census, the Iowa farm census, data from experimental farms and cooperative experiments with farmers, and from on-farm experience by soil scientists, extension workers, and others.

The yield predictions are meant to serve as guides. They are only approximate values and should be so considered. Of more value than actual yield figures to many users is the comparative yields among soils. These relationships are likely to remain consistent over a period of years, but actual yields have been increasing in recent years. If they continue to increase as expected, predicted yields in this table will soon be outdated.

Woodland Management[2]

Practices of woodland management commonly used in the county have resulted in gradual deterioration in the quality of trees. The early settlers prized the woodlands as sources of fuels, posts, and poles, and as material used in building houses and barns and in repairing implements. They harvested the best trees and left those less desirable in form and species. The less desirable trees gradually became dominant, and the value of the woodlands was reduced. Then the woodlands were liabilities instead of assets to many farm owners.

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[2] SYLVAN T. RUNKEL, biologist, Soil Conservation Service, Des Moines, Iowa, assisted in the preparation of this section.

TABLE 2.—*Predicted average acre yields of principal crops under high-level management*

[Absence of yields indicates soil is not suited to crop or crop is not ordinarily grown]

Soil	Corn	Soybeans	Oats	Alfalfa-grass hay	Pasture
	Bu/acre	*Bu/acre*	*Bu/acre*	*Tons/acre*	*Animal-unit days*[1]
Amana silty clay loam, 0 to 2 percent slopes	110	42	60	4.6	230
Amana complex, channeled, 0 to 2 percent slopes	90	34	50	3.8	190
Armstrong loam, 9 to 14 percent slopes, moderately eroded	59	22	37	2.5	125
Boone fine sandy loam, 18 to 40 percent slopes					20
Bremer silty clay loam, 0 to 2 percent slopes	106	40	58	4.5	225
Caleb loam, 9 to 14 percent slopes, moderately eroded	66	25	36	2.8	140
Caleb loam, 14 to 18 percent slopes, moderately eroded			20	1.9	95
Caleb loam, 18 to 25 percent slopes, moderately eroded				1.3	65
Chelsea loamy fine sand, 4 to 9 percent slopes	52	20	39	1.8	90
Chelsea loamy fine sand, 9 to 14 percent slopes, moderately eroded			30	1.5	75
Chelsea loamy fine sand, 14 to 18 percent slopes, moderately eroded				1.3	65
Chelsea loamy fine sand, 18 to 25 percent slopes, moderately eroded				1.3	65
Chelsea-Clinton complex, 5 to 9 percent slopes, moderately eroded	70	27	38	2.9	145
Chelsea-Clinton complex, 9 to 14 percent slopes, moderately eroded	60	23	33	2.5	125
Chelsea-Clinton complex, 14 to 18 percent slopes, moderately eroded				1.8	90
Clarinda silty clay loam, 5 to 9 percent slopes	63	24	34	2.6	130
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	55	21	30	2.2	110
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	46	17	25	1.8	90
Clearfield silty clay loam, 5 to 9 percent slopes	91	35	50	3.6	180
Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded	88	33	48	3.5	175
Clinton silt loam, 2 to 5 percent slopes	107	41	59	4.5	225
Clinton silt loam, 5 to 9 percent slopes	102	39	56	4.3	215
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	99	38	54	4.2	210
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	90	34	50	3.8	190
Clinton soils, 9 to 14 percent slopes, severely eroded	84	32	46	3.5	175
Clinton silt loam, 14 to 18 percent slopes, moderately eroded	75	29	41	3.2	160
Colo silt loam, overwash, 0 to 2 percent slopes	106	42	80	4.3	215
Colo silty clay loam, 0 to 2 percent slopes	104	40	78	4.2	210
Colo silty clay loam, 2 to 5 percent slopes	102	39	76	4.0	200
Colo-Ely silty clay loams, 2 to 5 percent slopes	95	36	52	4.0	200
Downs silt loam, benches, 2 to 5 percent slopes	119	45	95	5.0	250
Ely silty clay loam, 2 to 5 percent slopes	126	48	95	5.3	265
Fayette silt loam, 2 to 5 percent slopes	113	43	90	4.7	235
Fayette silt loam, 5 to 9 percent slopes, moderately eroded	105	40	84	4.4	220
Fayette silt loam, 9 to 14 percent slopes, moderately eroded	96	36	76	4.0	200
Fayette silt loam, 14 to 18 percent slopes, moderately eroded	81	31	65	3.4	170
Flagler fine sandy loam, 0 to 2 percent slopes	63	24	47	2.6	130
Gara loam, 9 to 14 percent slopes, moderately eroded	75	28	41	3.1	155
Gara loam, 14 to 18 percent slopes, moderately eroded				2.2	110
Gara loam, 18 to 25 percent slopes, moderately eroded				1.5	75
Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded	69	26	38	2.8	140
Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	60	23	33	2.4	120
Givin silt loam, 1 to 3 percent slopes	119	45	65	5.0	250
Givin silt loam, benches, 1 to 3 percent slopes	119	45	65	5.0	250
Gosport silt loam, 9 to 14 percent slopes					30
Gosport silt loam, 14 to 18 percent slopes					25
Gosport silt loam, 18 to 25 percent slopes					20
Grundy silty clay loam, 2 to 5 percent slopes	107	41	59	4.5	190
Grundy silty clay loam, 5 to 9 percent slopes, moderately eroded	102	39	56	4.3	185
Haig silt loam, 0 to 2 percent slopes	105	40	58	4.2	210
Hedrick silt loam, 2 to 5 percent slopes	109	41	60	4.6	230
Hedrick silt loam, 5 to 9 percent slopes	104	40	57	4.4	220
Hedrick silt loam, 5 to 9 percent slopes, moderately eroded	101	38	55	4.2	210
Hedrick silt loam, 9 to 14 percent slopes, moderately eroded	92	35	51	3.9	195
Hedrick silt loam, 14 to 18 percent slopes, moderately eroded	77	29	42	3.2	160
Humeston silt loam, 0 to 2 percent slopes	88	33	48	3.7	185
Huntsville silt loam, 0 to 2 percent slopes	125	48	93	5.2	260
Judson silty clay loam, 2 to 5 percent slopes	124	47	93	5.2	260
Judson silty clay loam, 5 to 9 percent slopes	119	45	90	5.0	250
Kennebec silt loam, 0 to 2 percent slopes	124	47	93	5.2	260
Ladoga silt loam, 2 to 5 percent slopes	113	43	62	4.7	235
Ladoga silt loam, 5 to 9 percent slopes	108	41	59	4.5	225
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	105	40	57	4.4	220
Ladoga silt loam, 9 to 14 percent slopes	99	38	54	4.2	210
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	96	36	53	4.0	200
Ladoga silt loam, benches, 2 to 5 percent slopes	113	43	62	4.7	235
Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded	105	40	57	4.4	220
Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	71	27	39	3.0	150
Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	61	23	33	2.6	130
Landes fine sandy loam, 0 to 2 percent slopes	81	31	44	3.4	170

TABLE 2.—*Predicted average acre yields of principal crops under high-level management*—Continued

Soil	Corn	Soybeans	Oats	Alfalfa-grass hay	Pasture
	Bu/acre	*Bu/acre*	*Bu/acre*	*Tons/acre*	*Animal-unit days*[1]
Lindley loam, 9 to 14 percent slopes, moderately eroded	72	27	40	3.0	150
Lindley loam, 14 to 18 percent slopes, moderately eroded	---	---	---	1.5	75
Lindley loam, 18 to 25 percent slopes, moderately eroded	---	---	---	1.0	50
Lindley-Keswick complex, 9 to 14 percent slopes, moderately eroded	50	---	28	2.0	100
Lindley-Keswick complex, 14 to 18 percent slopes, moderately eroded	---	---	---	1.5	75
Mahaska silty clay loam, 0 to 2 percent slopes	125	48	69	5.2	260
Mahaska silty clay loam, 2 to 5 percent slopes	119	45	65	5.0	250
Mahaska silty clay loam, benches, 1 to 3 percent slopes	125	48	69	5.2	260
Marsh	---	---	---	---	---
Mine pits and dumps	---	---	---	---	---
Nevin silty clay loam, 0 to 2 percent slopes	114	43	63	4.8	240
Nira silty clay loam, 2 to 5 percent slopes	114	43	63	4.8	240
Nira silty clay loam, 5 to 9 percent slopes	109	41	60	4.6	230
Nira silty clay loam, 5 to 9 percent slopes, moderately eroded	106	40	58	4.5	225
Nodaway silt loam, 0 to 2 percent slopes	114	43	63	4.8	240
Nodaway silt loam, channeled, 0 to 2 percent slopes	---	---	---	3.0	150
Nodaway-Alluvial land complex, 0 to 2 percent slopes	---	---	---	---	---
Nodaway-Vesser silt loams, 2 to 5 percent slopes	89	34	61	3.7	175
Olmitz loam, 2 to 5 percent slopes	100	38	55	4.2	210
Olmitz loam, 5 to 9 percent slopes	95	36	52	4.0	200
Ossian silt loam, 0 to 2 percent slopes	110	42	88	4.6	230
Otley silty clay loam, 2 to 5 percent slopes	119	45	65	5.0	250
Otley silty clay loam, 5 to 9 percent slopes	114	43	63	4.8	240
Otley silty clay loam, 5 to 9 percent slopes, moderately eroded	111	42	61	4.7	235
Otley silty clay loam, 9 to 14 percent slopes	105	40	57	4.4	220
Otley silty clay loam, 9 to 14 percent slopes, moderately eroded	102	39	56	4.3	215
Otley silty clay loam, benches, 2 to 5 percent slopes	119	45	65	5.0	250
Otley silty clay loam, benches, 5 to 9 percent slopes, moderately eroded	119	45	65	5.0	250
Pershing silt loam, 2 to 5 percent slopes	101	38	56	4.2	210
Pershing silt loam, 5 to 9 percent slopes, moderately eroded	91	35	50	3.8	190
Radford silt loam, 0 to 2 percent slopes	106	40	58	4.5	225
Riverwash	---	---	---	---	---
Rubio silt loam, 0 to 2 percent slopes	91	35	50	3.8	190
Seaton silt loam, 9 to 14 percent slopes, moderately eroded	96	36	76	4.0	200
Seaton silt loam, 14 to 18 percent slopes, moderately eroded	81	31	65	3.4	170
Seaton silt loam, 18 to 25 percent slopes, moderately eroded	---	---	---	3.2	160
Shelby loam, 9 to 14 percent slopes, moderately eroded	81	31	44	3.4	170
Shelby loam, 14 to 18 percent slopes, moderately eroded	66	25	36	2.7	135
Sogn silt loam, 18 to 40 percent slopes	---	---	---	---	50
Sparta loamy fine sand, 4 to 9 percent slopes	54	21	40	2.3	115
Sparta-Otley complex, 5 to 9 percent slopes, moderately eroded	85	32	46	3.6	180
Sparta-Otley complex, 9 to 14 percent slopes, moderately eroded	76	29	42	3.2	160
Sperry silt loam, 0 to 2 percent slopes	97	37	53	3.5	175
Spillville loam, 0 to 2 percent slopes	122	46	98	5.1	260
Spillville loam, sandy substratum, 0 to 2 percent slopes	95	36	78	4.0	200
Taintor silty clay loam, 0 to 2 percent slopes	117	44	64	4.7	235
Taintor silty clay loam, benches, 0 to 2 percent slopes	117	44	64	4.7	235
Tuskeego silt loam, 0 to 2 percent slopes	82	31	45	3.3	165
Vesser silt loam, 0 to 2 percent slopes	95	36	52	4.0	200
Vesser silt loam, 2 to 5 percent slopes	93	35	51	3.9	195
Watkins silt loam, 0 to 2 percent slopes	105	40	58	4.4	220
Watkins silt loam, 2 to 5 percent slopes	103	39	56	4.3	215
Weller silt loam, 5 to 9 percent slopes, moderately eroded	85	32	46	3.2	160
Wiota silt loam, 0 to 2 percent slopes	110	42	62	4.6	230
Zook silt loam, overwash, 0 to 2 percent slopes	101	38	55	4.2	210
Zook silty clay loam, 0 to 2 percent slopes	96	36	54	3.8	190
Zook silty clay loam, 2 to 5 percent slopes	94	35	52	3.7	185
Zook silty clay loam, depressional, 0 to 1 percent slopes	68	26	37	1.8	90

[1] The amount of forage or feed required to maintain 1 animal unit for a period of 1 day. The animal-unit-day used here is based on the assumption that one mature animal will consume 40 pounds of dry matter per pasture day. Yields are based on alfalfa-grass except for those soils where no hay yields are given. The yields from those soils are based on permanent bluegrass pasture.

The woodlands in the county are used mostly for pasture, and improving them is made more difficult by grazing. Some formerly wooded areas have been cleared for farming. Notable among these areas are the Lindley, Clinton, Keswick, and Chelsea soils, and some of the soils on bottom lands. Some of the more sloping areas are severely eroded and need to be replanted to suitable trees.

In woodlands the hardwoods are of such poor quality that the best procedure is to replace them with more valuable conifers. Before conifers are planted, however, inferior trees

and shrubs that might compete with the conifers should be eliminated by mowing or by spraying with some kind of chemical.

Soils vary in their suitability for trees, and trees vary in ability to grow in various kinds of soil and under various conditions of climate. Generally, the deep, well drained and moderately well drained soils that are medium to high in fertility are well suited to trees. The development of tree roots is related to the permeability of the subsoil. If roots are poorly developed because soil aeration and drainage are poor, trees do not develop normally above the ground.

Native hardwoods generally are not well suited to eroded soils or to soils that have been cultivated. Hardwoods grow better on soils that have not been cultivated, and pines are better suited to eroded or formerly cultivated soils.

Woodland suitability groups

The soils of Mahaska County have been placed in woodland groups according to their suitability for growing trees. Each group is made up of soils that have about the same characteristics and are subject to similar limitations or hazards. All of the soils in a group support similar kinds of trees, have about the same potential productivity, and require similar kinds of management.

Site index ratings are given for most of the woodland groups. The site index is the average height of the dominant and codominant trees in a stand at 50 years of age. It indicates potential soil productivity. Board foot production is estimated and based on the assumption that stands are fully stocked and well managed.

Each woodland group is also rated for hazards that need to be considered in management.

Erosion hazard is rated according to expected erosion that is a result of the cutting and removal of trees. It is *slight* if potential erosion is unimportant; *moderate* if some practices, such as those for diverting water, are needed to prevent accelerated erosion; and *severe* if intensive treatment is needed to control soil losses. Where erosion is severe, special care must be taken in locating and constructing roads and skid trails, in diverting water during and after logging, and in some places, in seeding grasses.

Seedling mortality refers to the expected loss of planted seedlings that is a result of unfavorable soil characteristics, not a result of plant competition. Mortality is *slight* if no more than 25 percent of the seedlings die, *moderate* if 25 to 50 percent of the seedlings die, and *severe* if more than 50 percent of the seedlings die.

Plant competition refers to the rate that unwanted brush, grass, vines, or other undesirable plants interfere with the establishment of planted or naturally occurring tree seedlings. Competition is *slight* if unwanted plants do not prevent adequate regeneration or interfere with the early growth of seedlings. Competition is *moderate* if invading plants delay but do not prevent the establishment of seedlings. Competition is *severe* if unwanted plants prevent the growth of the seedlings.

The system for ordinating soils according to woodland suitability is designed to provide guidance in placing kinds of soil into woodland suitability groups, insure uniformity of woodland suitability groupings within areas having similar soils and climate, and provide a uniform system of labeling woodland suitability groups that expresses some of the important soil-woodland interpretations. The system has three major categories: woodland suitability classes, subclasses, and groups.

Woodland suitability classes.—Woodland suitability classes are based on average site index of an indicator tree species of forest type for each soil. They represent the highest category of the system. Class 1 is potentially the highest in productivity, followed consecutively by classes 2, 3, 4 and so on, to include the entire site-index range of each forest type.

Woodland suitability subclasses.—Woodland suitability subclasses are the second category of the system. They are used for grouping soils within woodland suitability classes. Subclasses are based on selected soil properties that cause moderate to severe hazards or limitations in woodland use or management. A letter *w* shows that water in or on the soil, either seasonally or year round, is the chief limitation; *c* shows that the main limitation is the kind or amount of clay in the upper part of the soils in the group; *s* shows that the soils are sandy and dry, have little or no difference in texture between the surface layer and subsoil, have low available water capacity, and generally have a low supply of plant nutrients; *r* shows that the main limitation is steep slopes; and *o* shows that the soils have few limitations that restrict their use for trees. The subclass *t* (toxic substances) is not used in Mahaska County.

Woodland suitability groups.—Woodland suitability groups are the third category of the system. Woodland suitability groups within subclasses are numbered consecutively with Arabic numerals from 1 to as many as are needed. These numbers represent the third element of a symbol showing the complete ordination of each kind of soil, i.e., 1o1, 2o1, 5w1, 5w2, etc. The woodland suitability groups in Mahaska County are discussed in the following pages.

WOODLAND SUITABILITY GROUP 1o1

This group consists of medium-textured to moderately fine textured, deep, moderately well drained and well drained soils in the Clinton, Downs, Fayette, Hedrick, Judson, Ladoga, Nira, Otley, Seaton, Watkins, and Wiota series. The Clinton, Fayette, Hedrick, Ladoga, Nira, and Otley soils are on uplands and make up the largest acreages. The Watkins and Downs soils are on stream benches above the flood plain. The Judson soils are gently sloping. They are on foot slopes below the more sloping soils on uplands. Slopes for this woodland group range from 0 to 18 percent.

Permeability is moderate in the Downs, Fayette, Judson, Seaton, Wiota, and Watkins soils, and it is moderately slow in the Clinton, Hedrick, Nira, Ladoga, and Otley soils. All of the soils in this group have a high available water capacity.

Suitability of these soils for upland oaks is very high. The site index for upland oaks ranges from 76 to 85. Suitability for production of conifers and cottonwoods is very high. Estimated production on these soils from existing timber ranges from 250 to 300 (*10*) board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing hardwood stands are walnut, white oak, red oak, green ash, hard maple, basswood, and wild black cherry.

Erosion is a moderate hazard on Clinton, Ladoga, Nira, Otley, and Seaton soils and a slight hazard on Downs, Watkins, and Wiota soils. Except where runoff concentrates and small rills and gullies develop, little or no erosion is present on Judson soils. Seedling mortality is slight on all soils in this group, and it depends on the amount of damage done by soil-related insects and rodents. Plant competition from grass, weeds, or undesirable trees is slight to moderate.

Conifers most suitable for planting in woodlots on these

soils are eastern white pine, red pine, Norway spruce, Scotch pine, European larch, and eastern redcedar. Hardwoods most suitable for this use are walnut, green ash, hackberry, and hard maple. Conifers most suitable for windbreaks are eastern white pine, red pine, Norway spruce, white spruce, and eastern redcedar. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, cardinal autumn-olive, and dogwood.

WOODLAND SUITABILITY GROUP 2o1

This group consists of deep, well drained and moderately well drained soils in the Caleb, Gara, Lindley, Olmitz, and Shelby series. All of these soils except the Olmitz soils are on uplands. Olmitz soils are on lower areas and are gently sloping. Slopes for this woodland group range from 2 to 18 percent.

Permeability is moderate or moderately slow in the soils of this group. Available water capacity is high.

Suitability of these soils for upland oaks is high. The site index for upland oaks ranges from 66 to 75. Suitability for production of conifers is high, and for cottonwoods is very high. Estimated production on these soils from existing timber ranges from 200 to 249 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing hardwood stands are red oak, cottonwood, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Erosion is a moderate hazard on the Caleb, Gara, Lindley, and Shelby soils. Except where runoff concentrates and small rills or gullies develop, little or no erosion is present on Olmitz soils. Seedling mortality is generally slight on all soils in this group. Plant competition from grasses, weeds, or other undesirable plants is slight to moderate.

Conifers most suitable for planting in woodlots on these soils are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir. Hardwoods most suitable for this use are black walnut, green ash, and hackberry. Conifers most suitable for windbreaks are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, cardinal autumn-olive, and dogwood.

WOODLAND SUITABILITY GROUP 2r1

Only Seaton silt loam, 18 to 25 percent slopes, moderately eroded, is in this group. It is well drained, and is on uplands.

Permeability is moderate in the soils of this group. Available water capacity is high.

Suitability of this soil for upland oaks is high. The site index for upland oaks ranges from 66 to 75. Suitability for production of conifers and cottonwoods is high. Estimated production on this soil from existing timber ranges from 200 to 249 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing hardwood stands are black walnut, white oak, red oak, green ash, hard maple, basswood, and wild black cherry.

Erosion is a severe hazard on this soil. Seedling mortality is slight. Plant competition from grass is slight to severe. Equipment limitations are moderate or severe.

Conifers most suitable for planting in woodlots on this soil are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir. Hardwoods most suitable for this use are black walnut, green ash, and hackberry. Conifers most suitable for windbreaks are eastern white pine, red pine, Norway spruce, white spruce, and eastern redcedar. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, dogwood, and cardinal autumn-olive.

WOODLAND SUITABILITY GROUP 3r1

This group consists of medium-textured, deep, well drained and moderately well drained soils in the Caleb, Gara, and Lindley series. All of these soils are on uplands. Slopes for this woodland group range from 18 to 25 percent and generally face north and northeast.

Permeability is moderately slow in the soils of this group. Available water capacity is high. Runoff is rapid.

Suitability of the soils for upland oaks is moderately high. The site index for upland oaks ranges from 56 to 65. Suitability for production of conifers is moderately high, and for cottonwoods is high. Estimated production on these soils from existing timber ranges from 150 to 199 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Erosion is a severe hazard on these soils. Seedling mortality is generally slight. Plant competition from grasses, weeds, or other undesirable plants is moderate.

Conifers most suitable for planting in woodlots in these soils are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir. Hardwoods most suitable for this use are black walnut, green ash, and hackberry. Conifers most suitable for windbreaks are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, cardinal autumn-olive, and dogwood.

WOODLAND SUITABILITY GROUP 3w1

This group consists of medium-textured and moderately fine textured, deep, somewhat poorly drained soils in the Ely, Givin, Mahaska, and Nevin series. The Givin and Mahaska soils are on uplands. The gently sloping Ely soils are on foot slopes. The nearly level Nevin soils are on second bottoms. Slopes for this woodland group range from 0 to 5 percent.

Permeability is moderate or moderately slow in the soils of this group. Available water capacity is high. Runoff is slow.

Suitability of these soils for upland oaks and production of conifers is moderately high. Suitability for production of cottonwoods is high. The site index for hardwood trees ranges from 56 to 65. Estimated production on these soils ranges from 150 to 199 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing stands are green ash, hackberry, white oak, red oak, and cottonwood.

These soils are subject to little or no erosion. Seedling mortality is generally slight. Plant competition from undesirable species is moderate.

Conifers most suitable for planting in woodlots on these soils are eastern white pine, Scotch pine, red pine, Norway spruce, eastern redcedar, and European larch. Hardwoods most suitable for this use are green ash, walnut, and hackberry. Conifers most suitable for windbreaks are eastern white pine, Scotch pine, red pine, Norway spruce, and eastern redcedar. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for this use are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 4s1

This group consists of dominantly coarse-textured, deep, well-drained to excessively drained soils of the Chelsea, Clinton, Flagler, Otley, and Sparta series. All of these soils except the Flagler soil are on uplands. Flagler fine sandy loam is on bottom land and benches. The Chelsea and Sparta soils are coarse textured, and the Clinton and Otley soils are medium textured but are closely associated with coarse-textured, droughty soils. Slopes for this woodland group range from 0 to 25 percent.

Permeability is very rapid to moderately slow in the soils of this group. Available water capacity is low in the Flagler soils, low to very low in Chelsea and Sparta soils, and high in Clinton and Otley soils.

Suitability of these soils for upland oaks is moderate. The site index for upland oaks ranges from 46 to 55. Suitability for production of conifers and cottonwoods is moderately high. Estimated production on these soils from existing timber ranges from 100 to 149 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing stands are red oak, white oak, green ash, hackberry, and cottonwood.

Erosion is a moderate to severe hazard on all of these soils except the Flagler soil. Seedling mortality may be severe in some years because of droughty conditions. Plant competition from grasses, weeds, or other undesirable plants is slight to moderate.

Conifers most suitable for planting in woodlots on these soils are eastern white pine, red pine, Scotch pine, European larch, and eastern redcedar. Hardwoods most suitable for this use are green ash, walnut, and hackberry. Conifers most suitable for windbreaks are eastern white pine, red pine, Scotch pine, and eastern redcedar. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, cardinal autumn-olive, and dogwood.

WOODLAND SUITABILITY GROUP 4w1

This group consists of moderately fine textured and medium-textured, somewhat poorly drained and moderately well drained soils in the Grundy, Pershing, and Weller series. All of these soils are on uplands. Slopes for this woodland group range from 2 to 9 percent.

Permeability is slow in the soils of this group. Available water capacity is high.

Suitability of the soils for upland oaks is moderate. Suitability for production of conifers is moderate, and for cottonwoods is moderately high. The site index for upland hardwoods ranges from 46 to 55. Estimated production on these soils from existing timber ranges from 100 to 149 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing stands are green ash, hackberry, red oak, and white oak.

Hardwoods most suitable for planting in woodlots on these soils are soft maple, sycamore, green ash, and hackberry. Conifers most suitable for windbreaks are eastern white pine and eastern redcedar. Species suitable for wildlife planting are dogwood, buttonbush, and pussy willow.

WOODLAND SUITABILITY GROUP 5c1

Only Armstrong loam, 9 to 14 percent slopes, moderately eroded, is in this group. It is a medium textured, moderately well drained and somewhat poorly drained soil on uplands.

Permeability is slow. Available water capacity is high. Runoff is moderate to high.

Suitability of this soil for upland oaks is low. The site index on this soil for upland oaks is less than 45. Suitability for production of conifers and cottonwoods is moderate. Estimated production on this soil from existing timber is less than 100 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing stands are eastern white pine, Scotch pine, eastern redcedar, Norway spruce, green ash, hackberry, red oak, white oak, and cottonwood.

Erosion is a moderate to severe hazard. Seedling mortality is slight. Plant competition from undesirable plants is slight.

Conifers most suitable for planting in woodlots on this soil are eastern white pine, Scotch pine, eastern redcedar, and Norway spruce. Hardwoods most suitable for this use are green ash and hackberry. Conifers most suitable for windbreaks are eastern white pine, Scotch pine, eastern redcedar, and Norway spruce. Hardwoods most suitable for this use are Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks, and the hardwoods listed as suitable for this use are especially suitable for field windbreaks. Species suitable for wildlife planting are dogwood, buttonbush, and pussy willow.

WOODLAND SUITABILITY GROUP 5s1

This group consists of shallow, excessively drained soils in the Boone and Sogn series. Slopes for this woodland group range from 18 to 40 percent.

Runoff is rapid in the soils of this group. Available water capacity is very low and low.

Suitability of these soils for upland oaks is low. The site index for upland oaks is less than 45. Suitability for production of conifers and cottonwoods is low. Estimated production on these soils from existing timber is less than 100 board feet per acre per year in well-managed and fully stocked stands.

Trees that should be favored in existing hardwood stands are green ash, hackberry, red oak, and white oak.

Erosion is a moderate to severe hazard on these soils. Seedling mortality is slight to severe and depends on timeliness of rainfall.

Conifers most suitable for planting in woodlots on these soils are eastern white pine, Scotch pine, red pine, and European larch. Conifers most suitable for windbreaks are eastern white pine, Scotch pine, red pine, and eastern redcedar. Species suitable for wildlife planting are honeysuckle and ninebark.

WOODLAND SUITABILITY GROUP 5w1

This group consists of moderately fine textured, moderately well drained to poorly drained soils in the Clarinda, Gosport, and Lamoni series. All of these soils are on uplands. Slopes for this woodland group range from 5 to 25 percent.

Permeability is slow to very slow in the soils of this group. Available water capacity is high or moderate. Runoff is rapid. The soils in this group are seasonally wet and seepy.

Suitability of these soils for upland oaks is low. Suitability for production of conifers and cottonwoods is low. The site index for upland hardwoods is less than 45. Estimated production of the upland hardwoods on these soils from existing timber is less than 100 board feet per acre per year on well-managed and fully stocked stands.

Trees that should be favored in existing hardwood stands are green ash, hackberry, and cottonwood.

Erosion is a moderate to severe hazard on these soils. Seedling mortality and plant competition are slight.

Conifers most suitable for planting in woodlots on these soils are redcedar and Scotch pine. Hardwoods suitable for this use are green ash, hackberry, and cottonwoods. All of these trees are also suitable for windbreaks. The conifers listed are especially suitable for farmstead windbreaks, and the hardwoods are especially suitable for field windbreaks.

WOODLAND SUITABILITY GROUP 5w2

This group consists of deep, medium-textured or moderately coarse textured, well-drained to somewhat poorly drained soils in the Amana, Huntsville, Kennebec, Landes, Nodaway, Radford, and Spillville series and Alluvial land. All of these soils are on nearly level bottom land and are subject to flooding. Slopes for this woodland group range from 0 to 2 percent.

Permeability is mainly moderate in the soils of this group. Available water capacity is generally high, but in Landes soils and in Alluvial land it is mainly low. Runoff is slow.

Suitability of these soils for upland oaks is low. Suitability for production of conifers is low, and for bottom-land hardwoods is moderately high to high.

Trees that should be favored in existing stands on these soils are cottonwood, soft maple, and green ash. These soils are not well suited to upland hardwoods or conifers.

Erosion is not normally a hazard on these soils. Some gullies form where water concentrates in drainageways. Plant competition is slight, and seedling mortality is generally slight.

Bottom-land hardwoods most suitable for planting in woodlots and in windbreaks on these soils are cottonwood, soft maple, and green ash. Species suitable for wildlife planting are dogwood, buttonbush, and pussy willow.

WOODLAND SUITABILITY GROUP 5w3

This group consists of medium-textured and moderately fine textured, poorly drained soils in the Bremer, Clearfield, Colo, Ely, Haig, Humeston, Ossian, Rubio, Sperry, Taintor, Tuskeego, Vesser, and Zook series. All of these soils are on uplands or bottom lands. Slopes for this woodland group range from 0 to 5 percent.

Permeability is slow or very slow in the soils of this group. Available water capacity is high. The Amana, Bremer, Colo, Humeston, Ossian, and Vesser soils are subject to flooding, and the Rubio, Sperry, and Tuskeego soils are subject to ponding from runoff.

Suitability of these soils for upland oaks and conifers is low. Suitability for production of cottonwoods is moderate or high. The soils on bottom lands are better suited to trees than the soils on uplands. Estimated production on these soils ranges from 200 to 500 board feet per acre per year in the existing well-managed and fully stocked stands on bottom land.

Trees best suited to planting in woodlots on these soils are soft maple, cottonwood, sycamore, willow, green ash, and hackberry. Conifers are not well suited to this use. Trees most suitable for windbreaks are cottonwood, soft maple, and green ash. Cottonwood and soft maple are particularly well suited to windbreaks. Species suitable for wildlife planting are dogwood, buttonbush, and pussy willow.

Wildlife[3]

In Mahaska County, as elsewhere, the kinds and amounts of wildlife depend considerably on the kinds of soil, though this relationship between the soils and wildlife is not always easily distinguished. The soils affect wildlife through their influence on the vegetation that grows and supplies food and cover for wildlife.

Many practices used principally to improve the soil and the practices that increase crop production also benefit wildlife. Contour stripcropping and alternation of crops in a cropping system provide a mixture of cover and increase the amount of food and cover that wildlife can use. During the winter, cover crops and crop residues are used by wildlife for food and cover. Diversion terraces and grassed waterways provide travel lanes and nesting places. Fertilization and liming increase the supply of food and cover available for use by wildlife. Farm ponds are very beneficial to wildlife, especially where they are fenced to keep livestock out of the water.

A well-planned and well-managed system of farming maintains the productivity of the soils and provides a good supply of food and cover for wildlife. A poorly managed farm that depletes the soil by erosion also reduces the supply of food and the amount of cover that is available to wildlife. The resulting reduction in the population of desirable animals and birds leads to an increase in the number of insects, rodents, and other destructive animals.

On most farms, habitat for wildlife can be improved by

[3] SYLVAN T. RUNKEL, biologist, Soil Conservation Service, assisted in the preparation of this section.

increasing, distributing, and diversifying the supply of food, water, and cover, and by providing travel lanes.

Few farms in Mahaska County have an ideal balance between food, water, and cover for wildlife. Most farms are used mainly for row crops and hay. On these farms food and cover for wildlife are abundant in part of the year, but cover is likely to be scarce in winter and early in spring. Where fall plowing is practiced, the supply of food and cover is greatly reduced in this critical time. Burning vegetation in roadside ditches in fall also causes a needless loss of food and cover for wildlife. A few farms in Mahaska County are largely in pasture. On these farms the distances between areas with a good supply of food and cover is often too great for good wildlife habitat.

Cropland, pasture, and woodland can all be managed in a way that will provide an adequate supply of food, water, and cover available for wildlife in all seasons of the year. On cropland, cover can be provided by fence rows, shelter belts, shrub rows, and perennial field borders and by vegetation in waterways and on the banks of ditches or streams. In addition to these places of cover, odd areas in fields and around ponds and small wet areas can be used for both food and cover. In pasture or woodland, borders that produce seed and wild fruit can be planted along fence lines, around ponds, and in odd areas (fig. 26). Idle land around old pit mines and spoil banks that has grown up to weeds, grass, shrubs, and trees is heavily used by wildlife.

All the soils in Mahaska County are suitable for producing some kinds of wildlife. For economic reasons, wildlife is considered as a secondary crop by farmers on all but the poorest land, and on land covered by water.

The kinds and number of wildlife that live in an area are related to the kinds of soil, vegetation, and other environmental factors. For this reason, the kinds of wildlife in Mahaska County are discussed in relation to the seven soil associations, which are described in the section "General Soil Map."

Figure 26.—**A planting of multiflora rose used for wildlife food and cover on Clinton silt loam.**

Mahaska County is in the transition area between bobwhite quail to the south and pheasant to the north. The greatest number of bobwhite quail are in soil associations 3, 4, and 6. The greatest pheasant population is in soil associations 1, 2, and 5.

Cottontail rabbits are plentiful and are the most hunted game animal. They are in all seven soil associations, but they are the most numerous in brushy areas interspersed with cropland and pasture.

The greatest populations of squirrel, red fox, and whitetail deer are in wooded areas along the valleys of rivers and creeks in soil associations. Squirrel, fox, and deer also are commonly seen in wooded pastures in soil associations 3 and 6.

Among the fur-bearing game animals are raccoon, beaver, muskrat, mink, skunk, and opossum. They are in the greatest number along the valleys of soil association 5.

Hawks, owls, and small birds are attracted to wooded areas throughout the county.

A few coyote and badger are in Mahaska County. They are seen most often in soil associations 2, 3, and 4.

During the season of migration, ducks and geese are attracted to rivers and ponds in all parts of the county.

Fish are common in rivers, streams, and ponds. The principal sport fish are catfish, bass, bluegill, bullhead, and crappie.

Use of the Soils for Recreation

Soil properties that affect the use of soils for recreation purposes are the texture, the degree of stoniness, the depth to hard bedrock or shale, the steepness of slopes, permeability, wetness, and the hazard of flooding. Other factors that influence the recreational use of soils include the recreation needs of population centers close to the area; the natural scenic qualities of the area; well-known landmarks or historic sites in the area; the size and location of rivers, streams, and lakes; and the location and types of roads in or near the area.

Consideration of these factors indicates that Mahaska County has some potential for recreational development. Therefore the requirements made of soils in the county for recreational purposes will increase in the future.

The nature of occurrence and the properties of soils, abrupt changes in topography, and the vegetation in Mahaska County provide favorable recreational sites. Areas with rough topography in close proximity to fertile, intensively farmed land add to the scenic interest and to the potential value of the land for wildlife and for outdoor sports.

A number of recreational facilities have been developed in the county. Red Rock Dam is located just outside the northwest corner of the county. It is expected to increase the need for camping, cabin, boating, and fishing facilities along the Des Moines River.

The Des Moines and Skunk Rivers are in association 5. They provide good catfish, bullhead, and carp fishing. Lake Keomah and the park located east of Oskaloosa have facilities for fishing, boating, swimming, hiking, camping, and picnicing. In winter the park is a popular place for sledding, ice skating, and ice fishing.

A 160-acre lake is planned for the northeast part of Mahaska County, south of Barnes City. This lake will be of

Figure 27.—**Farm pond in Mahaska County.**

benefit to many kinds of wildlife. It will also provide recreation to the surrounding areas. The lake will be in soil association 3.

Farm ponds, generally 1 to 3 acres in size, are scattered throughout the county (fig. 27). Technical assistance for the construction of such ponds is provided by the Soil Conservation Service. Most ponds are stocked with catfish, bass, or blue gill. Many of them are stocked with bullhead. The ponds are beneficial to wildlife, and they help to control erosion and provide recreation. Most pond sites are in soil associations 3 or 4.

Hunting takes place in all seven soil associations in the county. Common game species include quail, pheasant, duck, goose, rabbit, deer, raccoon, and squirrel.

Idle land around some abandoned coal mines in soil association 4 has been placed in public hunting areas (fig. 28). Food and cover plantings have been made in some of these to attract species such as rabbit, squirrel, quail, and pheasant. Idle land around pits and spoil banks has grown up to trees, shrubs, weeds, and grass.

The water in the old coal mine pits is generally of very poor quality. Over the years the water in some of these has improved in quality, and fish have become established.

In 1969, a strip-mine reclamation project covering about 50 acres was set up about 3 miles west of Oskaloosa for research and demonstration purposes. Slopes were graded to bring the grade to 12 percent or less. The spoil material and soil material in the area were limed, fertilized, and seeded to provide an area that could be used by wildlife. This also improved the appearance of the area and is expected to provide limited recreation.

A wildlife area of a unique type has been established about 2 miles north of Fremont in an enclosed pasture around a farm pond. Animals and fowl that are kept to be observed and appreciated are: buffalo, elk, lama, burrow, sheep, ducks, and geese. Several kinds of deer and exceptional species of cattle are also on this site.

The rolling topography, fertile soils, and good moisture supply make soil association 2 particularly adapted to the development of challenging golf courses.

The potential for expansion of recreational facilities includes the development of vacation farms, the sale of hunting privileges on farms where good wildlife habitat is maintained during the entire year, target and trap shooting areas for different types of guns and for bow and arrow, and a golf driving range, and improved management of farm ponds and local lakes for fish or for ducks and geese.

Engineering Uses of the Soils[4]

For a long time engineers have studied soil properties that affect construction and have devised systems of soil classification based on these characteristics. Most of these studies

[4] VOLNEY H. SMITH, assistant State conservation engineer, Soil Conservation Service, Des Moines, Iowa, assisted in the preparation of this section.

Figure 28.—**Idle land around spoil banks of coal mine is heavily used by wildlife and hunters.**

have been at the site of construction because general information about the soils of an area has not been available.

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, facilities for storing water (fig. 29), erosion control structures, irrigation systems, drainage systems, building foundations, and sewage disposal systems. Among the properties that are most important are permeability, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and reaction (pH). Also important are depth to the water table, depth to bedrock, and topography.

The information in this survey can be used by engineers to:

1. Make studies of soil and land use that will aid in the selection and development of industrial, business, residential, and recreational sites.
2. Assist in planning and designing drainage and irrigation structures and in planning dams and other structures for water and soil conservation.
3. Make preliminary evaluation of soil and ground conditions that will aid in selecting highway and airport locations and in planning more detailed investigations at the selected locations.
4. Locate probable sources of sand, gravel, or other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information for planning that will be useful in designing and maintaining specified engineering structures.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports, and from aerial photographs, for the purpose of making maps and reports that can be readily used by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

With the use of the soil map for identification, the interpretations in this survey can be useful to the planning engineer. It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads or where the excavations are deeper than the depth of layers reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Information regarding the properties and behavior of the soils in Mahaska County can be obtained from the detailed soil map at the back of this survey and from tables 3 and 4.

Figure 29.—**Farm pond being constructed on Lindley soils.**

The information in the tables was obtained in the field and was evaluated by observation of soil performance and by considering the results of tests such as those shown in table 5. A specific value in pounds per square foot should not be assigned to the ratings of bearing capacity.

Some of the terms used by soil scientists may have a special meaning in soil science and may be unfamiliar or have a special meaning to engineers. Many of these terms are defined in the Glossary at the back of this survey. Information valuable to engineers is also in the sections "Descriptions of the Soils" and "Formation and Classification of Soils."

Engineering classification systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (AASHO) (*1*). In this system soil materials are classified on the basis of field performance in seven principal groups. The groups range from A-1, consisting of gravelly soil of high bearing capacity, to A-7, which is made up of clayey soils having low strength when wet.

Some engineers prefer to use the Unified Soil Classification System (*17*). In this system, soil materials are identified as coarse grained (eight classes), fine grained (six classes), or highly organic (one class). An approximate classification can be made in the field. Estimated classification of the soils in Mahaska County, under both systems, is given in table 3.

Engineering properties of the soils

In table 3, the soil series in Mahaska County are listed and estimates of soil properties are given. These estimates are based on the test data in table 5, on information in other parts of this survey, and on experience with the same kind of soil in other counties.

Depth to bedrock is not given in table 3, because bedrock, in most soils in the county, is at a depth of more than 5 feet. The Boone soil, however, has soft sandstone at a depth of about 8 inches, and the Sogn soil has fractured limestone at a depth of about 14 inches.

Depth to a seasonal high water table is important because it indicates soils that may be seasonally wet or flooded.

In table 3, the soils of the county are classified according to the dominant texture of layers at specified depths. The United States Department of Agriculture defines texture as the proportion of sand, silt, and clay. The soils are also classified according to the Unified and AASHO systems. The percentage of material passing No. 4, 10, and 200 sieves is the normal range in percentage of soil particles passing the respective screens.

Permeability refers to the rate of movement of water through the undisturbed soil. Permeability depends largely on the soil texture and structure.

Available water capacity is estimated in inches per inch of soil depth. It is the approximate amount of water in the soil, when it is wet to field capacity, that can be removed by plants. These estimates are of particular value to engineers engaged in irrigation.

Reaction is the degree of acidity or alkalinity, expressed as a pH value. The pH of a neutral soil is 7.0, of an acid soil is less than 7.0, and of an alkaline soil is more than 7.0.

Shrink-swell potential indicates the change in volume that occurs with a change in moisture content. These soil materials rated high normally are undesirable for use in engineering, because the increase in volume that occurs when dry soil is wetted normally is accompanied by a loss in bearing capacity. In general, soils classed as CH and A-7 have a high shrink-swell potential. Clean sand and gravel (structureless, single grained) and soils having small amounts of nonplastic to slightly plastic fines have a low shrink-swell potential.

Engineering interpretations of the soils

In table 4 the soils in Mahaska County are rated according to their suitability as a source of topsoil and road fill, and soil features affecting highway location, foundations for low buildings, farm ponds, agricultural drainage, terraces and diversions, grassed waterways, septic-tank disposal fields, and sewage lagoons are given.

None of the soils in the county are suitable as sources of gravel, and most of them do not have enough sand that is suitable for construction purposes. The Boone soil, however, has poorly graded sand and is fairly well suited to well suited as construction material; the Chelsea, Flagler, Landes, and Sparta soils have poorly graded sand that is suited. Riverwash along the Des Moines River is the primary source of sand for local use. Riverwash varies from place to place from poorly graded to well graded, but it is predominantly poorly graded.

"Shear strength," mentioned in table 4, indicates the relative resistance of the soil to sliding when supporting a load. The highest resistance to sliding occurs in soils that are composed of clean gravel. Soil strength decreases as fines increase and is lowest in fine-grained organic soils. "Bearing capacity" is the ability of a soil to support a load. For large structures field tests on soils are directed to the determination of the sizes of footings or foundations, with or without piling, needed to support the design loadings or structure in service, without obtaining uneven or excessive settlement during or after construction. "Compressibility" pertains to the decrease in volume of the mass when supporting a load. Compressibility is lowest in coarse-grained soils. It is highest in fine-grained soils that contain organic matter.

TABLE 3.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such other series that appear in the first column of this table. The

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Alluvial land. Properties are too variable for valid estimates. Mapped only in a complex with Nodaway soil.					
Amana: 422, C422	1–3	0–16	Silty clay loam	ML or CL	A-6(8-12) to A-7-6(10-14)
		16–64	Silty clay loam	ML or CL	A-7-6(10-14)
		64–72	Silt loam	ML	A-6(8-12)
Armstrong: 792D2	(1)	0–14	Loam	CL	A-6(8-12)
		14–23	Clay loam	CL or CH	A-6(10) to A-7-6(14)
		23–35	Clay	CH	A-7-6(15-20)
		35–60	Clay loam	CL	A-6(8) to A-7-6(16)
Boone: 210G	>5	0–5	Fine sandy loam or loamy fine sand.	SM	A-2-4 or A-3-0
		5–14	Loamy fine sand and sand	SM or SW	A-2-4
		14	Sandstone.		
Bremer: 43	1–3	0–25	Silty clay loam	ML or CH	A-7-6(12-16)
		25–60	Silty clay	CH	A-7-6(16-20)
		60–100	Silty clay loam	CL or CH	A-7-6(13-17)
Caleb: 451D2, 451E2, 451F2	>5	0–19	Loam or sandy loam	CL	A-4(6-10)
		19–49	Sandy clay loam	CL or SC	A-4(4) to A-6(10)
		49–81	Loamy sand to loam	SM or CL	A-2-4 to A-4-6(6-10)
*Chelsea: 63C, 63D2, 63E2, 63F2, 293C2, 293D2, 293E2. For properties of Clinton soils in mapping units 293C2, 293D2, and 293E2, refer to the Clinton series.	>5	0–34	Loamy fine sand	SM	A-2-4(0)
		34–62	Fine sand	SM or SP-SM	A-2-4(0)
Clarinda: 222C, 222C2, 222D2	(1)	0–12	Silty clay loam	CL	A-6(6-10) to A-7-6(14)
		12–53	Clay	CH	A-7-6(20)
		53–96	Clay	CH	A-7-6(16-20)
Clearfield: 69C, 69C2	(1)	0–15	Silty clay loam	ML-CL	A-7-6(13-18)
		15–54	Silty clay loam	CH	A-7-6(15-20)
		54–66	Clay	CH	A-7-6(20)
Clinton: 80B, 80C, 80C2, 80D2, 80D3, 80E2	>5	0–12	Silt loam	ML-CL	A-4(8) to A-6(12)
		12–34	Silty clay loam	CL or CH	A-7-6(14-18)
		34–60	Silty clay loam	CL or CH	A-7-6(12-16)
*Colo: 133+, 133, 133B, 11B. For properties of Ely soil in mapping unit 11B, refer to the Ely series.	1–3	0–33	Silty clay loam	CL or CH	A-7-5 or A-7-6(14-20)
		33–68	Silty clay loam	CL or CH	A-7-6(14-20)
		68–87	Loam	ML-CL	A-4(8) to A-6(12)
Downs: T162B	>5	0–14	Silt loam	ML or CL	A-4(6) to A-6(10)
		14–36	Silty clay loam	CL	A-7-6(10–14)
		36–72	Silty clay loam	CL	A-6(8) to A-7-6(12)

significant to engineering

mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to symbol > means more than; the symbol < means less than]

Percentage passing sieve— No. 4 (4.7 mm)	Percentage passing sieve— No. 10 (2.0 mm)	Percentage passing sieve— No. 200 (0.074 mm)	Permeability	Available water capacity	Reaction	Shrink-swell potential
			Inches per hour	*Inches per inch of soil*	*pH value*	
	100	95–100	0.6–2.0	0.20	5.6–7.0	Moderate.
	100	95–100	0.6–2.0	0.19	5.6–6.5	Moderate.
	100	95–100	0.6–2.0	0.17	6.1–6.5	Moderate.
95–100	70–90	60–75	0.6–2.0	0.18	5.6–6.5	Moderate.
95–100	80–95	55–80	0.2–0.6	0.16	5.1–6.0	Moderate.
95–100	80–95	55–80	0.06–0.2	0.14	5.1–6.0	High.
95–100	80–95	55–70	0.2–0.6	0.15	5.1–5.5	Moderate.
	100	5–35	2.0–6.3	0.10	5.6–6.0	Low.
	100	5–12	>6.3	0.05	5.1–6.0	Very low.
	100	95–100	0.2–0.6	0.21	6.6–7.3	Moderate to high.
	100	95–100	0.06–0.2	0.20	6.1–7.3	High.
	100	95–100	0.2–0.6	0.18	6.6–7.3	High.
90–100	80–100	50–65	0.6–2.0	0.17	5.1–6.0	Low to moderate.
85–100	80–100	40–70	0.6–2.0	0.14	4.5–5.5	Moderate.
85–100	75–90	10–65	2.0–20.0	0.08	4.5–6.0	Low.
100	95–100	10–35	2.0–6.0	0.08	5.1–6.5	Low.
100	95–100	8–20	6.0–20.0	0.05	5.1–5.5	Low.
100	95–100	85–100	0.2–0.6	0.18	5.1–5.5	Moderate to high.
95–100	90–100	80–90	<0.06	0.15	5.1–7.3	High.
95–100	90–100	75–90	<0.06	0.15	6.6–7.3	High.
100	100	95–100	0.2–0.6	0.21	6.6–7.3	Moderate to high.
100	100	95–100	0.2–0.6	0.19	6.6–7.3	High.
95–100	90–100	80–90	<0.06	0.15	6.6–7.3	High.
	100	95–100	0.6–2.0	0.18	5.1–7.3	Moderate.
	100	95–100	0.2–0.6	0.18	5.1–6.0	Moderate to high.
	100	95–100	0.6–2.0	0.18	5.1–6.0	Moderate to high.
	100	85–100	0.2–0.6	0.22	6.6–7.3	High.
	100	85–100	0.2–0.6	0.18	6.6–7.3	High.
	100	80–100	0.6–2.0	0.18	6.6–7.3	Moderate to high.
	100	95–100	0.6–2.0	0.20	6.1–6.5	Moderate.
	100	95–100	0.6–2.0	0.18	5.6–6.0	Moderate to high.
	100	95–100	0.6–2.0	0.17	5.1–6.0	Moderate to high.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Ely: 428B	2–5	0–25	Silty clay loam	CL	A-7-6(12-15)
		25–58	Silty clay loam	CL	A-7-6(12-15)
		58–70	Silty clay loam	CL	A-7-6(12-15) or A-6(10-12)
Fayette: 163B, 163C2, 163D2, 163E2	>5	0–9	Silt loam	ML or CL	A-4(8) to A-6(12)
		9–47	Silty clay loam	CL	A-7-6(12-15)
		47–60	Silt loam	CL	A-6(8) to A-7-6(12)
Flagler: 284	1–3	0–22	Fine sandy loam and sandy loam.	SM or SC	A-4(1-5) to A-2-4
		22–33	Sandy loam	SM or SC	A-2-4 to A-4(1-5)
		33–65	Loamy sand with some gravel	SM or SP-SM	A-2-4(0)
*Gara: 179D2, 179E2, 179F2, 993D2, 993E2. For properties of Armstrong soils in mapping units 993D2 and 993E2, refer to the Armstrong series.	>5	0–12	Loam	CL	A-4(3) to A-6(8)
		12–44	Clay loam	CL or CH	A-6(9) to A-7-6
		44–60	Clay loam	CL	A-6(10) to A-7-6(16)
Givin: 75, T75	2–5	0–12	Silt loam	ML or CL	A-6(10) to A-7-6(13)
		12–69	Silty clay loam	CL to CH	A-7-6(14-18)
		69–93	Silt loam	ML or CL	A-6(10) to A-7-6(13)
Gosport: 313D, 313E, 313F	>5	0–8	Silt loam	ML or CL	A-6(10) to A-7-6(13)
		8–30	Silty clay	CH	A-7-6(20)
		30–60	Silty clay shale	CH	A-7-6(20)
Grundy: 364B, 364C2	2–5	0–19	Silty clay loam	ML or CL	A-7-6(12-18)
		19–31	Silty clay	CH	A-7-6(20)
		31–96	Silty clay loam	CL or CH	A-7-6(10-16)
Haig: 362	1–3	0–23	Silt loam or silty clay loam	ML or CL	A-6(9) to A-7-6(13)
		23–43	Silty clay	CH	A-7-6(20)
		43–54	Silty clay loam	CL	A-7-6(12-15)
Hedrick: 571B, 571C, 571C2, 571D2, 571E2	>5	0–8	Silt loam	ML or CL	A-6(10) to A-7-6(14)
		8–53	Silty clay loam	CL or CH	A-7-6(10-16)
		53–94	Silt loam or silty clay loam	CL	A-6(10) to A-7-6(16)
Humeston: 269	1–3	0–20	Silt loam	ML or CL	A-6(8) to A-7-6(18)
		20–60	Silty clay	CH	A-7-6(17-20)
		60–80	Silty clay loam	CL	A-6(10) to A-7-6(16)
Huntsville: 98	>5	0–24	Silt loam	ML or CL	A-4(8) to A-6(10)
		24–45	Silt loam	ML or CL	A-4(8) to A-6(10)
		45–65	Clay loam	CL	A-6(8-12)
		65–92	Silt loam	CL	A-6(6-10)
Judson: 8B, 8C	>5	0–24	Silty clay loam	ML or CL	A-6(9) to A-7-6(13)
		24–47	Silty clay loam	CL	A-6(10) to A-7-6(12)
		74–96	Silt loam	ML-CL	A-4(8) to A-6(10)

significant to engineering—Continued

Percentage passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)	Permeability	Available water capacity	Reaction	Shrink-swell potential
			Inches per hour	*Inches per inch of soil*	*pH value*	
----------------	100	95–100	0.6–2.0	0.21	6.1–6.3	Moderate to high.
----------------	100	95–100	0.6–2.0	0.20	6.1–7.3	Moderate to high.
----------------	100	95–100	0.6–2.0	0.18	6.6–7.3	Moderate to high.
----------------	100	95–100	0.6–2.0	0.19	5.6–6.5	Moderate.
----------------	100	95–100	0.6–2.0	0.18	5.1–6.5	Moderate to high.
----------------	100	95–100	0.6–2.0	0.17	5.1–5.5	Moderate.
----------------	100	25–50	2.0–6.0	0.12	5.6–7.3	Low.
----------------	100	30–40	2.0–6.0	0.08	5.1–7.3	Low.
85–95	70–95	5–20	6.0–20.0	0.04	5.1–6.5	Very low.
85–95	80–90	55–70	0.6–2.0	0.18	5.6–6.0	Moderate.
85–95	80–90	55–75	0.2–0.6	0.17	5.6–6.0	Moderate.
85–95	80–90	55–75	0.2–0.6	0.16	5.6–6.0	Moderate.
----------------	100	95–100	0.6–2.0	0.19	6.6–7.3	Moderate.
----------------	100	95–100	0.2–0.6	0.18	5.1–6.0	Moderate to high.
----------------	100	95–100	0.6–2.0	0.17	6.1–6.5	Moderate.
----------------	100	85–100	0.6–2.0	0.18	4.5–6.0	Moderate.
----------------	100	85–100	<0.06	0.14	4.5–6.0	High.
----------------	100	85–100	<0.06	0.06	5.1–6.0	High.
----------------	100	95–100	0.6–2.0	0.20	5.6–6.0	Moderate to high.
----------------	100	95–100	0.06–0.2	0.15	5.6–6.0	High.
----------------	100	95–100	0.2–0.6	0.16	5.6–6.5	Moderate to high.
----------------	100	95–100	0.6–2.0	0.20	6.6–7.3	Moderate.
----------------	100	95–100	<0.06	0.18	5.6–6.0	High.
----------------	100	95–100	0.06–0.2	0.20	5.6–6.0	High.
----------------	100	95–100	0.6–2.0	0.19	6.6–7.3	Moderate.
----------------	100	95–100	0.2–0.6	0.19	5.6–6.5	Moderate to high.
----------------	100	95–100	0.2–0.6	0.18	6.1–7.3	Moderate to high.
----------------	100	95–100	0.2–0.6	0.18	6.1–6.5	Moderate to high.
----------------	100	95–100	<0.06	0.15	5.1–6.0	High.
----------------	100	95–100	0.2–0.6	0.17	5.6–6.0	High.
----------------	100	95–100	0.6–2.0	0.22	5.6–7.3	Moderate.
----------------	100	95–100	0.6–2.0	0.20	5.6–6.0	Moderate.
----------------	90–100	70–100	0.6–2.0	0.17	6.1–6.5	Moderate to high.
----------------	95–100	85–100	0.6–2.0	0.17	6.1–6.5	Moderate.
----------------	100	95–100	0.6–2.0	0.22	6.1–7.3	Moderate.
----------------	100	95–100	0.6–2.0	0.20	5.6–6.5	Moderate.
----------------	100	95–100	0.6–2.0	0.18	6.6–7.3	Moderate.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Kennebec: 212	2–5	0–49	Silt loam	ML or CL	A-6(8) to A-7-6(14)
		49–70	Light silty clay loam	CL	A-6(8) to A-7-6(14)
Keswick. Mapped only in a complex with Lindley soil.	(1)	0–8	Loam	CL	A-6(8-12)
		8–32	Clay and heavy clay loam	CH	A-7-6(14-20)
		32–63	Clay loam	CL	A-6(6-12)
Ladoga: 76B, 76C, 76C2, 76D, 76D2, T76B, T76C2.	>5	0–10	Silt loam	ML-CL	A-6(10) to A-7-6(14)
		10–60	Silty clay loam	CL	A-6(10) to A-7-6(18)
Lamoni: 822C2, 822D2	(1)	0–14	Silty clay loam	CL or ML	A-6(10) to A-7-6(12)
		14–32	Light clay and light silty clay	CH	A-7-6(16-20)
		32–62	Clay loam	CL	A-6(10) to A-7-6(15)
Landes: 208	>5	0–22	Fine sandy loam	SM or SC	A-2 or A-4
		22–60	Very fine sandy loam and loamy fine sand	SM	A-4 or A-2-4
*Lindley: 65D2, 65E2, 65F2, 424D2, 424E2. For properties of Keswick soils in mapping units 424D2 and 424E2, refer to the Keswick series.	>5	0–8	Loam	CL	A-4(3) to A-6(8)
		8–35	Clay loam	CL	A-6(9) to A-7-6(14)
		35–61	Clay loam	CL	A-6(6-10)
Mahaska: 280, 280B, T280	2–5	0–14	Silty clay loam	ML-CL	A-7-6(12-16)
		14–55	Silty clay loam	CH	A-7-6(16-20)
		55–96	Silty clay loam	CL	A-7-6(14-18)
Marsh: 354	0	0–60	Variable	OH or Pt-ML	A-7-5 or A-7-6
Mine pits and dumps: 502. Properties are too variable for valid estimates.					
Nevin: 88	2–5	0–26	Silty clay loam	ML-CL	A-6(9) to A-7-6(14)
		26–57	Silty clay loam	CL or CH	A-7-6(12-18)
		57–72	Silty clay loam	CL	A-6(10) to A-7-6(16)
Nira: 570B, 570C, 570C2	>5	0–13	Silty clay loam	ML or CL	A-7-6(8-10)
		13–48	Silty clay loam	CL or CH	A-7-6(10-16)
		48–84	Silt loam	CL	A-6(10) to A-7-6(12)
*Nodaway: 13B, 220, C220, 315. For properties of Vesser soils in mapping unit 13B, refer to the Vesser series. The properties of Alluvial land in unit 315 are too variable for valid estimates.	2–5	0–46	Silt loam	ML or CL	A-4(8) to A-6(10)
		46–96	Silty clay loam	CL	A-6(10) to A-7-6(12)
Olmitz: 273B, 273C	2–5	0–29	Loam and clay loam	CL	A-6(6) to A-7-6(12)
		29–55	Clay loam	CL	A-6(8) to A-7-6(12)
		55–70	Sandy clay loam	SC or CL	A-6(4-12)
Ossian: 489	1–3	0–7	Silt loam	ML or CL	A-7-6(10-14)
		7–46	Silty clay loam	ML or CL	A-7-6(12-16)
		46–96	Silty clay loam	ML or CL	A-7-6(10-14)

significant to engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
	100	95–100	0.6–2.0	0.20	6.1–7.3	Moderate.
	100	95–100	0.6–2.0	0.19	6.6–7.3	Moderate.
90–100	80–100	60–80	0.6–2.0	0.18	5.6–6.0	Moderate.
90–100	80–100	55–80	0.06–0.2	0.16	5.1–6.0	High.
90–100	80–100	50–70	0.2–0.6	0.17	6.6–7.3	Moderate to high.
	100	95–100	0.6–2.0	0.20	6.1–6.5	Moderate.
	100	95–100	0.2–0.6	0.18	5.6–6.5	Moderate to high.
95–100	90–100	70–95	0.2–0.6	0.19	5.6–6.5	Moderate to high.
95–100	80–100	75–90	<0.06	0.15	5.1–6.0	High.
85–100	80–100	55–85	0.06–0.2	0.16	5.6–6.0	High.
100	80–90	25–50	2.0–6.0	0.12	6.6–7.3	Low.
100	75–90	20–45	6.0–20.0	0.08	6.6–7.3	Low.
85–95	80–90	55–65	0.6–2.0	0.17	5.6–6.5	Moderate.
85–95	80–90	50–65	0.2–0.6	0.16	5.1–6.0	Moderate.
85–95	80–90	50–65	0.2–0.6	0.16	7.3–8.4	Moderate.
	100	95–100	0.6–2.0	0.22	6.1–7.3	Moderate to high.
	100	95–100	0.2–0.6	0.20	5.6–7.3	High.
	100	95–100	0.2–0.6	0.18	6.6–7.3	Moderate to high.
Variable	Variable	Variable	Variable	Variable	Variable	Moderate to high.
100	95–100	90–100	0.6–2.0	0.22	6.1–7.3	Moderate to high.
100	95–100	90–100	0.2–0.6	0.20	6.1–7.3	High.
100	95–100	90–100	0.6–2.0	0.18	6.6–7.3	Moderate to high.
	100	95–100	0.6–2.0	0.20	6.6–7.3	Moderate.
	100	95–100	0.2–0.6	0.18	6.1–7.3	Moderate to high.
	100	95–100	0.6–2.0	0.17	6.6–7.8	Moderate.
100	95–100	90–100	0.6–2.0	0.19	6.6–7.3	Moderate.
100	95–100	90–100	0.6–2.0	0.19	6.6–7.3	Moderate.
100	90–100	60–80	0.6–2.0	0.20	5.6–6.5	Moderate.
100	90–100	60–80	0.2–0.6	0.18	5.6–6.5	Moderate.
90–100	70–90	40–60	0.6–2.0	0.16	6.6–7.3	Moderate.
100	95–100	90–100	0.6–2.0	0.20	6.6–7.3	Moderate.
100	95–100	90–100	0.6–2.0	0.18	6.1–7.3	Moderate to high.
100	95–100	90–100	0.6–2.0	0.17	6.6–7.3	Moderate to high.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Otley: 281B, 281C, 281C2, 281D, 281D2, T281B, T281C2.	>5	0–16	Silty clay loam	CL or ML	A-6(10) to A-7-6(13)
		16–54	Silty clay loam	CL or CH	A-7-6(12-18)
		54–70	Silt loam	ML or CL	A-6(10) to A-7-6(14)
Pershing: 131B, 131C2	>5	0–15	Silt loam	ML or CL	A-4(8) to A-6(10)
		15–38	Silty clay and silty clay loam	CH	A-7-6(14-20)
		38–48	Silty clay loam	CL or CH	A-6(10) to A-7-6(14)
Radford: 467	2–5	0–29	Silt loam	ML or CL	A-4(8) to A-6(10)
		29–88	Silty clay loam and silty clay	CL or CH	A-7-6(14-18)
Riverwash: 53. Properties are too variable for valid estimates.					
Rubio: 74	0–2	0–16	Silt loam	ML or CL	A-4(6) to A-6(10)
		16–49	Silty clay loam and silty clay	CL or CH	A-7-6(14-20)
		49–96	Silt loam	ML or CL	A-6(10) to A-7-6(12)
Seaton: 663D2, 663E2, 663F2	>5	0–13	Silt loam	ML	A-4(4-8)
		13–45	Silt loam	ML or CL	A-6(6-10)
		45–72	Silt loam	ML or CL	A-4(4-8)
Shelby: 24D2, 24E2	>5	0–10	Loam	CL	A-6(8) to A-7-6(16)
		10–44	Clay loam	CL	A-6(8) to A-7-6(14)
		44–72	Clay loam	CL	A-6(8) to A-7-6(12)
Sogn: 412G	>5	0–14	Silt loam and silty clay loam	ML or CL	A-4(6) to A-6(10)
		14	Fractured limestone.		
*Sparta: 41C, 442C2, 442D2. For properties of Otley soils in mapping units 442C2 and 442D2, refer to the Otley series.	>5	0–18	Loamy fine sand	SM	A-2-4(0)
		18–60	Loamy sand and sand	SM or SP-SM	A-2-4(0)
Sperry: 122	0–2	0–17	Silt loam	ML or CL	A-6(8-10)
		17–53	Silty clay loam and silty clay	CH	A-7-6(16-20)
		53–96	Silty clay loam	CL	A-7-6(12-16)
Spillville: 485	2–5	0–37	Loam	CL or OL	A-6(8-12)
		37–58	Clay loam	CL	A-6(8-12)
Spillville, sandy substratum: 270	2–5	0–40	Loam to light silty clay loam to loam.	CL	A-6(8-12)
		40–60	Fine sand or loamy fine sand	SM or SP-SM	A-2-4(0)
Taintor: 279, T279	1–3	0–17	Silty clay loam	CL or CH	A-7-6(13-19)
		17–61	Silty clay and silty clay loam	CH	A-7-6(18-20)
		61–96	Silt loam	ML or CL	A-6(8-12)
Tuskeego: 453	1–3	0–13	Silt loam	ML or CL	A-4(6) to A-6(8)
		13–27	Silty clay loam	CL or CH	A-7-6(14-18)
		27–48	Silty clay	CH	A-7-6(18-20)
		48–90	Silty clay loam	CL or CH	A-7-6(14-20)

significant to engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
	100	95–100	0.6–2.0	0.21	6.1–7.3	Moderate.
	100	95–100	0.2–0.6	0.19	6.1–6.5	Moderate to high.
	100	95–100	0.6–2.0	0.18	6.1–6.5	Moderate to high.
	100	95–100	0.6–2.0	0.20	5.1–6.0	Moderate.
	100	95–100	0.06–0.2	0.18	4.5–5.0	High.
	100	95–100	0.2–0.6	0.17	5.1–5.5	Moderate to high.
100	95–100	90–100	0.6–2.0	0.19	6.6–7.3	Moderate.
	100	90–100	0.2–0.6	0.18	6.1–6.6	Moderate to high.
	100	95–100	0.6–2.0	0.18	6.1–6.5	Moderate.
	100	95–100	<0.06	0.18	5.1–6.5	High.
	100	95–100	0.6–2.0	0.17	6.6–7.3	Moderate.
	100	95–100	0.6–2.0	0.18	5.6–6.0	Moderate.
	100	95–100	0.6–2.0	0.17	5.6–7.3	Moderate.
	100	95–100	0.6–2.0	0.17	6.6–7.8	Moderate.
90–100	85–95	50–65	0.6–2.0	0.18	6.6–7.3	Moderate.
90–100	85–95	50–70	0.2–0.6	0.16	5.6–6.5	Moderate.
90–100	85–95	50–70	0.2–0.6	0.16	6.6–7.3	Moderate.
95–100	85–95	50–75	0.6–2.0	0.18	6.6–8.4	Moderate.
100	95–100	10–35	2.0–6.0	0.08	5.6–6.0	Low.
100	95–100	10–30	>20.0	0.05	5.6–6.0	Very low.
	100	95–100	0.6–2.0	0.18	5.6–7.3	Moderate.
	100	95–100	<0.06–0.2	0.19	5.6–7.3	High.
	100	95–100	0.2–0.6	0.18	6.6–7.3	Moderate to high.
95–100	90–100	55–80	0.6–2.0	0.20	6.6–7.3	Moderate.
95–100	90–100	55–80	0.6–2.0	0.18	6.6–7.3	Moderate.
100	95–100	55–80	0.6–2.0	0.20	6.0–7.3	Moderate.
	80–100	5–20	6.3–20.0	0.05	6.6–7.3	Very low.
	100	95–100	0.2–0.6	0.22	6.1–7.3	Moderate to high.
	100	95–100	0.2–0.6	0.20	6.1–6.5	High.
	100	95–100	0.6–2.0	0.18	6.1–6.5	Moderate.
	100	95–100	0.6–2.0	0.19	5.6–6.0	Moderate.
	100	95–100	0.06–0.20	0.18	5.6–6.0	Moderate to high.
	100	95–100	<0.06	0.15	6.6–7.3	High.
	100	95–100	0.06–0.20	0.17	6.6–7.3	Moderate to high.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification: Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Vesser: 51, 51B	2–5	0–33	Silt loam	ML or CL	A-6(8-12)
		33–50	Silty clay loam	CL	A-7-6(18-20)
		50–90	Silty clay and silty clay loam	CL	A-7-6(14-20)
Watkins: 687, 687B	>5	0–18	Silt loam	ML or CL	A-6(6-10)
		18–55	Silty clay loam	CL	A-7-6(10-14)
		55–80	Silty clay loam	CL	A-7-6(10-14)
		80–96	Clay loam	CL	A-7-6(10-14)
Weller: 132C2	>5	0–9	Silt loam	ML-CL	A-4(8) to A-6(10)
		9–34	Silty clay loam or silty clay	CH	A-7-6(18-20)
		34–54	Silty clay loam	CL	A-6(12) to A-7-6(14)
Wiota: 7	>5	0–24	Silt loam	ML or CL	A-4(8) to A-6(10)
		24–48	Silty clay loam	CL or CH	A-6(10) to A-7-6(16)
		48–71	Silty clay loam	CL or CH	A-6(8) to A-7-6(19)
Zook: 54+, 54, 54B, 248	1–3	0–21	Silty clay loam	CL or CH	A-7-6(15-19)
		21–48	Silty clay loam	CH	A-7-6(20)
		48–86	Silty clay loam	CL	A-7-6(15-20)

[1] Soils seasonally wet because of seepage from more permeable soil upslope.

Engineering test data

Soil samples were taken, by horizons, from two series and tested according to standard AASHO procedures to help evaluate the soils for engineering purposes. The tests were made by the Iowa State Highway Commission. The data are given in table 5. Because the samples tested were obtained at a depth of 5 feet or less, they do not represent materials that are encountered at a greater depth.

The relationship between the moisture content and the density of compacted soil material, as determined by the test explained in AASHO Designation T 99-57 (*1*), is given in table 5 in the columns headed moisture-density. The density, or unit weight, of the compacted dry soil increases as the content of moisture increases until the optimum moisture content is reached. After that, the density decreases with each increase in moisture content. The highest density obtained in the test is at the optimum moisture content and is the maximum density. As a rule, optimum stability is obtained if the soil is compacted to about the maximum density when the soil is at or near the optimum moisture content.

The liquid limit and the plasticity index indicate the effect of moisture on the consistence of the soil material. As the moisture content of a dry, clayey soil is increased, the material changes from a semisolid state to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from the plastic to the liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Soil features affecting highway work[5]

Many of the soils in Mahaska County formed in loess that overlies glacial till. The loess ranges from as much as 15 feet on the nearly level upland divides to a thin layer in the more sloping dissected areas. In many places where slopes are more than 15 percent, the loess is very thin or absent and the glacial till crops out on the surface.

The glacial till in Mahaska County has a relatively high in-place density. It is relatively stable at any moisture content and can be compacted readily to high density. The textural composition varies, but when the material is dry there are enough fines and coarse material to provide a firm riding surface that has little rebound after loading. The glacial till has good bearing capacity when compacted to maximum practical density.

The Mahaska, Taintor, Givin, and other soils that were derived from loess in nearly level areas have a fine-textured B horizon, or subsoil, that is classified A-7 (CL or CH). These soils have high group index numbers. The surface layer of the Mahaska and Taintor soils is high in content of organic matter and is difficult to compact to high density. The subsoil is plastic silty clay or silty clay loam that expands readily and does not make a good upper subgrade. Other soils derived from loess are the more sloping Clinton, Ladoga, and

[5] By DONALD A. ANDERSON, soil engineer, Iowa State Highway Commission.

significant to engineering—Continued

Percentage passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)	Permeability	Available water capacity	Reaction	Shrink-swell potential
			Inches per hour	*Inches per inch of soil*	*pH value*	
---------------	100	95–100	0.6–2.0	0.20	5.6–7.3	Moderate.
---------------	100	95–100	0.2–0.6	0.18	5.6–6.0	Moderate to high.
---------------	100	95–100	0.2–0.6	0.16	5.6–6.0	Moderate to high.
---------------	100	95–100	0.6–2.0	0.18	5.6–6.5	Moderate.
---------------	100	90–100	0.6–2.0	0.18	5.1–6.0	Moderate.
---------------	100	90–100	0.6–2.0	0.17	5.6–6.0	Moderate to high.
100	95–100	70–80	0.6–2.0	0.17	5.6–6.0	Moderate to high.
---------------	100	95–100	0.6–2.0	0.18	5.6–6.5	Moderate.
---------------	100	95–100	0.06–0.2	0.15	5.1–6.0	High.
---------------	100	95–100	0.2–0.6	0.16	5.6–6.0	Moderate to high.
---------------	100	85–100	0.6–2.0	0.20	5.6–7.3	Moderate.
---------------	100	85–100	0.6–2.0	0.18	5.6–6.0	Moderate to high.
---------------	100	70–100	0.6–2.0	0.16	5.6–6.0	Moderate to high.
---------------	100	95–100	0.2–0.6	0.19	6.6–7.3	Moderate to high.
---------------	100	95–100	0.06–0.20	0.17	6.1–6.6	High.
---------------	100	95–100	0.2–0.6	0.17	6.6–7.3	Moderate to high.

Otley soils. These soils have a plastic silty clay loam subsoil. They are classified A-7 (CL or CH) and have a fairly high group index. Loessal soils erode readily where runoff is concentrated. Sodding, paving, or check dams may be needed in gutters and ditches to help control excessive erosion.

In these soils derived from loess, the seasonal water table generally is above the contact of the loess and the highly weathered glacial till. Subdrains in the back slope help to intercept seepage. In the more nearly level areas a perched water table occurs within 1 to 3 feet of the surface. In these soils the in-place density of the loess is fairly low and the moisture content is high. The content of moisture can cause instability in embankment unless it is controlled enough to permit the soil to be compacted to high density.

Underlying the loess in the more level areas is weathered Kansan till, which is called gumbotil. Kansan till is fairly uniform and of poor quality for road construction work. In the more sloping parts of the county, this highly weathered glacial till is the present land surface. The Clarinda, Lamoni, Adair, Armstrong, and Keswick soils formed from the highly weathered glacial till. These soils have a plastic, highly weathered silty clay or clay subsoil and are classified as A-7-6 (18-20). This clay material is highly expansive, and it should not be used in parts of fills within 5 feet of a finished grade. If this clay material occurs at grade in roadcuts, it should be replaced with a backfill of less weathered glacial till, such as that in the Shelby, Gara, and Lindley soils.

Below these clayey layers is a heterogeneous Kansan till that is classified primarily A-6 or A-7 (CL). This till crops out on the lower part of slopes and is the parent material of Gara, Lindley, and Shelby soils. If this till occurs in or along grading projects, it generally is placed in the upper subgrade in unstable areas. Pockets and lenses of sand commonly are interspersed throughout the till and in many places are water bearing. Frost heaving is likely if the road grade is only a few feet above these deposits of sand and the deposits are overlain by loess or loamy till. Frost heaving can be prevented by replacing the soil above them with a backfill of coarse-textured material or with dense glacial clay till.

The soils on bottom lands developed from recent alluvium. Of these soils, the Colo, Ely, Judson, Zook, Humeston, Amana, and Vesser have a surface layer that is high in content of organic matter and consolidates unevenly under an embankment load. They have low in-place density and a high moisture content. Consequently, these soils should be carefully analyzed if an embankment is to be more than 15 feet high. Roadways through the bottom lands should be constructed on a continuous embankment that is above the level of floods.

Beds of limestone, sandstone, and shale crop out mainly along the Des Moines and Skunk Rivers and their tributaries. The Sogn soils developed in the areas of limestone. The beds of sandstone are discontinuous across Mahaska County and crop out in only a few places along the Des Moines and Skunk Rivers. The Boone soils occur in the sandstone outcrops. The shale occurs principally in the southwest quarter of the county, though there are a few small areas in other parts. The shale contains thin lenses of sandstone, limestone, and coal, and the soil above it slides in some places. Embankments on and parallel to shale at shallow depth should have the shale cut into benches to remove the sliding plane. Subdrains may be needed at the soil-shale contact on back slopes to remove seepage water. Shale is exposed only in the strongly dissected areas of Gosport soils along the Des

TABLE 4.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such other series that appear in the

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Alluvial land. Mapped only in a complex with Nodaway soil.	Variable: check each site.	Variable: some areas contain stratified fine sand and medium sand.	Unsuitable	Good to poor: check each site.	Nearly level; subject to frequent flooding; high water table.	Frequent flooding; high water table.
Amana: 422, C422.	Good: high in content of organic matter; medium textured.	Unsuitable	Unsuitable	Poor: low bearing capacity; poor workability; high content of organic matter.	Nearly level: seasonal high water table; subject to flooding; surface layer high in content of organic matter; poor foundation for high fills.	Flooding likely; high compressibility; low bearing capacity.
Armstrong: 792D2.	Fair in upper 1 foot, poor below: clayey subsoil.	Unsuitable	Unsuitable	Poor in subsoil: large volume change; highly expansive; fair in substratum: easily compacted.	Rolling; seepage can be expected seasonally in cuts; difficult to vegetate.	Low compressibility; uneven consolidation; often seepy and wet; high shrink-swell potential.
Boone: 210G	Poor	Poor	Unsuitable	Good: sandstone bedrock at depth of less than 2 feet; limited amount of borrow available.	Steep; material easily eroded; low plasticity; sandstone bedrock at depth of less than 2 feet.	Sandstone bedrock at depth of less than 2 feet.
Bremer: 43	Fair in upper 1½ feet, poor below: clayey subsoil.	Unsuitable	Unsuitable	Very poor: low bearing capacity; difficult to compact; high in content of organic matter.	Nearly level; low value as a potential source of borrow; high water table; subject to flooding; surface layer high in content of organic matter; not suitable for high fills.	High shrink-swell potential; high compressibility; poor shear strength; high water table; low bearing capacity.
Caleb: 451D2, 451E2, 451F2.	Fair: low in fertility; sandy clay loam subsoil.	Fair or poor: pockets of well to poorly graded sand in substratum in places.	Poor: few pockets of poor gravel in substratum in places.	Good: medium to high bearing capacity; low compressibility; easily compacted.	Strongly sloping to steep: good source of borrow; seepage in some cuts; low in content of organic matter.	Medium to high bearing capacity and shear strength; low compressibility; uneven consolidation.

engineering properties of the soils

mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to first column of this table.]

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Variable soil properties; suitable site unlikely.	Variable soil properties; not used for embankment because of position in landscape.	Adequate outlets difficult to establish in many places; land leveling needed; flood protection needed.	Nearly level bottom land.	Nearly level bottom land.	Severe: subject to frequent flooding; frequent high water table.	Severe: large variations in permeability; stratified material.
Suitable site unlikely; level; fluctuating water table.	Low stability when wet; high compressibility; fair to poor compaction characteristics; poor resistance to piping.	Moderate permeability; tile drainage suitable; surface drainage needed in places; flood protection needed.	Soil features favorable; properly placed diversions to control runoff reduce wetness in some areas; terraces not needed.	Nearly level	Severe: seasonal high water table; subject to flooding, especially in spring.	Severe: subject to flooding.
Very slow permeability when compacted; easily compacted.	Impervious material; fair to good stability; moderate to high shrink-swell potential; good for impervious cores; easily compacted.	Wet because of seepage; interceptor tile placed above seepage areas is helpful.	Subsoil unfavorable for crop growth; exposed subsoil difficult to vegetate; terrace channels likely to be seepy.	Low fertility; tile needed in many waterways to control seepage.	Severe: slow permeability, seasonally wet and seepy.	Severe: slopes more than 9 percent.
Sandstone bedrock at depth of less than 2 feet.	Highly impervious material; susceptible to piping; erodible.	Agricultural drainage not needed.	Steep; sandstone bedrock at depth of less than 2 feet.	Steep or very steep slopes; erodible; difficult to vegetate; low fertility.	Severe: slopes commonly exceed 15 percent; cemented sandstone near depth of 2 feet.	Severe: sandstone bedrock at depth of less than 2 feet.
Subject to flooding; slow permeability when compacted; suitable site unlikely except for dug ponds.	Fair stability; poor compaction; high shrink-swell potential.	Slow permeability; tile drains function poorly to satisfactorily; outlets difficult to obtain in places.	Nearly level bottom land; properly placed diversions to control local runoff reduce wetness in some areas.	Nearly level bottom land.	Severe: subject to flooding; slow permeability; seasonal high water table.	Moderate: slow permeability; high in content of organic matter.
Slow permeability when compacted; coarse strata are below a depth of 4 feet in places.	Good stability; easily compacted; usable for core material; slow permeability when compacted; good workability.	Moderately well drained.	Slopes commonly more than 9 percent; subsoil low in fertility.	Low fertility; difficult to vegetate; tile needed to control seepage in places.	Severe: slopes more than 9 percent; poor filtering material below depth of 4 feet.	Severe: slopes more than 9 percent.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
*Chelsea: 63C, 63D2, 63E2, 63F2, 293C2, 293D2, 293E2. For interpretations of the Clinton soils in mapping units 293C2, 293D2, and 293E2, refer to the Clinton series.	Poor: low in content of organic matter.	Fair: poorly graded fine sand.	Unsuitable	Good: low shrink-swell potential; good workability unless fines are less than 15 percent of soil; lacks stability under wheel loads when damp.	Sloping: highly erodible; difficult to vegetate; loose sand may hinder hauling operations; seepage in some deep cuts.	Low compressibility; fair to good shear strength; deep to water table; rapid consolidation; cuts may slump and flow if excavations are below water table.
Clarinda: 222C, 222C2, 222D2.	Fair in upper 1 foot, poor below: clayey subsoil.	Unsuitable	Unsuitable	Very poor: high shrink-swell potential; low bearing capacity when wet; difficult to compact.	Rolling: low values as potential source of borrow; seepage often in cuts; surface layer high in content of organic matter.	High shrink-swell potential; uneven consolidation; wet and seepy.
Clearfield: 69C, 69C2.	Fair in upper 2 to 3 feet, poor below: high clay content.	Unsuitable	Unsuitable	Very poor: high compressibility; fair to poor compaction characteristics; clayey substratum should not be placed in upper embankments.	Rolling: low value as potential source of borrow; seepage often in cuts; surface layer high in content of organic matter.	Poor shear strength; seasonally wet and seepy.
Clinton: 80B, 80C, 80C2, 80D2, 80D3, 80E2.	Good to about 1 foot, fair below: low in content of organic matter.	Unsuitable	Unsuitable	Poor: poor shear strength medium bearing capacity; moderate to high shrink-swell potential.	Rolling: high content of moisture in deep cuts likely; low value as a potential source of borrow; uniform silty material.	Poor shear strength; medium bearing capacity; moderate compressibility; uniform consolidation.
*Colo: 11B, 133+, 133, 133B. For interpretations of Ely soil in mapping unit 11B, refer to the Ely series.	Fair to good: high in content or organic matter except where overwash is present.	Unsuitable	Unsuitable	Very poor: low bearing capacity; poor shear strength; seasonal high water table; high compressibility; high in content of organic matter to a depth of about 3 feet or more.	Nearly level; seasonal high table; subject to some flooding; poor foundation for high fills.	Seasonal high water table; subject to flooding in most places; high compressibility with uneven consolidation.
Downs: T162B	Good in upper 1 foot, fair below: low in content of organic matter below upper 1 foot.	Unsuitable	Unsuitable	Fair to poor: low shear strength; medium bearing capacity; difficult to compact.	Gently undulating; low value as a potential source of borrow; low-density material.	High compressibility; medium bearing capacity; poor shear strength.

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Material is too porous to hold water.	Highly erodible; low shrink-swell potential; poor resistance to piping; seepage rate high.	Excessively drained.	Soil highly erodible; difficult to build and maintain ridges and channels.	Highly erodible; low available water capacity; difficult to vegetate.	Slight to moderate where slopes are less than 9 percent, severe where slopes are greater than 9 percent: severe danger of contamination of streams or water supplies.	Severe: rapid permeability.
Very slow permeability where compacted.	Fair stability on flat slopes; high shrink-swell potential.	Very slow permeability; properly placed interceptor tile help control seepage in some areas.	Low fertility; subsoil difficult to vegetate.	Difficult to vegetate subsoil; top dressing needed; seepage difficult to control.	Severe: very slow permeability; seasonal high water table.	Moderate where slopes are less than 9 percent, severe where slopes are more than 9 percent; very slow permeability.
Very slow permeability where compacted; suitable sites unlikely.	Fair stability on flat slopes; high shrink-swell potential; moderate compressibility.	Very slow permeability in substratum; properly placed interceptor tile needed.	Seasonal wetness and high water table often hinder construction; artificial drainage needed.	Difficult to vegetate where subsoil is exposed; top dressing often needed.	Severe: very slow permeability in substratum; seepy with a seasonal high water table.	Moderate: fluctuating water table.
Slow permeability where compacted; slow seepage rate; good sites normally available.	Fair stability; moderate to high expansion potential; fair or poor compaction.	Moderately well drained.	Soil features favorable; erodible cuts need to be held to a minimum to prevent exposure of less productive subsoil.	Soil features favorable; tile needed along side drainageways to prevent seepage.	Moderate to severe: moderately slow permeability.	Moderate where slopes are less than 9 percent, severe where slopes are more than 9 percent; moderately slow permeability.
High in content of organic matter; small areas suitable for dugout ponds; material stratified at depths of 6 feet or below in some places.	High in content of organic matter in top 3 feet or more; poor embankment foundation; moderate to high expansion potential.	Moderately slow permeability; tile drains satisfactory; outlets difficult to obtain in places; needs flood protection in places.	Soil features favorable; properly placed diversions to control runoff help prevent wetness in some places.	Soil features favorable; tile drains needed to keep waterways dry; vegetation easily established.	Severe: seasonal high water table; generally subject to some flooding; moderately slow permeability.	Severe: seasonal high water table; subject to flooding; high in content of organic matter.
Moderate uncompacted permeability; suitable sites unlikely; may be stratified below depths of 10 feet.	Poor stability; poor compaction; moderate shrink-swell potential.	Well drained------	Soil features favorable.	Soil features favorable.	Slight: moderate permeability.	Moderate: moderate permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Ely: 428B	Good: thick layer high in content of organic matter.	Unsuitable	Unsuitable	Poor: difficult to compact; low bearing capacity; moderate to high shrink-swell potential.	Gently sloping; high in content of organic matter; seasonal high water table; subject to short local flooding or overflow.	Low bearing capacity; moderate to high compressibility; subject to short local floods.
Fayette: 163B, 163C2, 163D2, 163E2.	Good in upper 4 to 8 inches; fair below: low in content of organic matter.	Unsuitable	Unsuitable	Fair to poor: low shear strength; medium bearing capacity; difficult to compact.	Gently undulating to rolling; low value as a potential source of borrow: low-density material.	High compressibility; medium bearing capacity; poor shear strength.
Flagler: 284	Fair in upper 2 feet, coarse below.	Fair to good	Poor	Good: high bearing capacity; stable under wheel loads when damp; very low compressibility; low shrink-swell	Nearly level: good potential source of borrow; good workability except where fines are less than 15 percent of soil; high content of moisture in some deep cuts.	Low compressibility; fair shear strength; high bearing capacity; may flow if saturated.
*Gara: 179D2, 179E2, 179F2, 993D2, 993E2. For interpretations of Armstrong soils in mapping units 993D2 and 993E2, refer to the Armstrong series.	Fair to good in upper 1 foot, poor below: low in content of organic matter.	Unsuitable	Unsuitable	Good: high bearing capacity; good workability and compaction; easily compacted to high density.	Rolling; variable material in cuts; some cuts seepy in places; good as potential source of borrow.	High bearing capacity; high shear strength; low compressibility; uneven consolidation.
Givin: 75, T75	Good in upper 1 foot, fair below: subsoil high in content of clay.	Unsuitable	Unsuitable	Very poor: low bearing capacity; poor shear strength; difficult to compact.	Nearly level; seasonal high water table; low value as potential source of borrow.	Moderate to high compressibility; seasonal high water table.

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Moderate uncompacted permeability; difficult to compact.	High in content of organic matter; difficult to compact; moderate or high compressibility.	Moderate permeability; wet because of seepage; interceptor tile needed.	Soil features favorable; diversions properly placed help protect from overflow and siltation.	Soil features favorable; tile needed to prevent seepage and establish vegetation.	Moderate: seasonal high water table.	Moderate: moderate permeability; high in content of organic matter.
Moderate uncompacted permeability.	Poor stability; poor compaction; fair to poor resistance to piping.	Well drained	Soil features favorable.	Soil features favorable.	Slight limitations where slopes are less than 5 percent; moderate where slopes are 5 to 9 percent; and severe where slopes are more than 9 percent: moderate permeability.	Moderate limitations where slopes are less than 9 percent, severe where slopes are more than 9 percent: moderate permeability.
Material too porous to hold water.	Fair stability; pervious when compacted; low volume change on wetting; susceptible to piping.	Somewhat excessively drained; sand and gravel substratum.	Sandy subsoil difficult to vegetate; erodible cuts need to be held to a minimum.	Highly erodible; difficult to vegetate.	Severe: poor filtering material permits unfiltered sewage to travel long distances; suitable if in sparsely populated areas or if wells are not nearby; seasonal high water table in places.	Severe: moderately rapid to rapid permeability.
Slow permeability when compacted; good sites available in most places.	Adequate stability; easily compacted; good workability; good for cores.	Wetness due to seepage; interceptor tile needed to control seepage at loess-till contact line.	Moderately thin or thin topsoil; cuts need to be held to a minimum because of the less productive subsoil.	Difficult to vegetate; tile needed to keep waterways dry in order to establish vegetation.	Severe: moderately slow permeability.	Severe: slopes more than 9 percent.
Suitable site unlikely; slow compacted permeability.	Poor stability when wet; moderate to high shrink-swell potential; high compressibility.	Moderately slow permeability; tile drains; satisfactory surface drains beneficial in depressional areas.	Nearly level	Features favorable; nearly level	Severe: seasonal high water table; moderately slow permeability.	Moderate: moderately slow permeability; seasonal high water table.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Gosport: 313D, 313E, 313F.	Poor: high in content of clay; low productivity.	Unsuitable	Unsuitable	Very poor to unsuitable: low bearing capacity and shear strength; high shrink-swell potential; high compressibility; laminated shale in substratum.	Rolling; very poor to unsuitable for borrow; often wet and seepy; sliding possible.	Low shear strength; low bearing capacity; high compressibility and shrink-swell potential; seasonal high water table; dangerous expansion potential if initially dry.
Grundy: 364B, 364C2.	Fair in surface layer, poor in clayey subsoil.	Unsuitable	Unsuitable	Very poor: high shrink-swell potential; low bearing capacity; poor compaction; seasonal high water table.	Gently or moderately sloping; seasonal high water table; poor workability and compaction when wet; low value as potential source of borrow.	Medium bearing capacity; moderate to high compressibility; uniform consolidation; seasonal high water table.
Haig: 362	Fair in upper 1–1½ feet, poor below: subsoil high in content of clay.	Unsuitable	Unsuitable	Very poor: high shrink-swell potential; low bearing capacity when wet; poor shear strength.	Nearly level; seasonal high water table; low value as potential source of borrow.	High compressibility; high shrink-swell potential; seasonal high water table.
Hedrick: 571B, 571C, 571C2, 571D2, 571E2.	Good in surface layer, fair below; low in content of organic matter in subsoil.	Unsuitable	Unsuitable	Poor: moderate to high shrink-swell potential; very low bearing capacity when wet; difficult to compact.	Rolling; low value as potential source of borrow; high content of moisture in some deep cuts.	High compressibility; subject to frost-heave and subsequent loss of strength on thawing; poor shear strength.
Humeston: 269	Fair in upper part: often wet; very poor in clayey subsoil.	Unsuitable	Unsuitable	Very poor: high elasticity; low bearing capacity when wet; poor shear strength; high shrink-swell potential.	Nearly level; low value as potential source of borrow; subject to flooding; seasonal high water table; high in content or organic matter; poor foundation for high fills.	Subject to flooding; high water table; high shrink-swell potential.
Huntsville: 98	Good: thick layer high in content of organic matter.	Unsuitable	Unsuitable	Poor: poor shear strength; low bearing capacity; difficult to compact.	Nearly level: low value as potential source of borrow; low-density material.	High compressibility; low bearing capacity; poor shear strength.

properties of the soils—Continued

Soil features affecting—Continued						Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways		Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment						
Very slow permeability; occasionally mixed with sandstone which may need a seal blanket.	Clayey subsoil and shaley substratum have high shrink-swell potential and may tend to creep in embankments; very slow permeability.	Clayey subsoil; strongly sloping to moderately steep.	Clayey, infertile soil.	Very difficult to vegetate; clayey subsoil low to very low in fertility and strongly acid.		Severe limitations; very slow permeability in the subsoil and substratum.	Moderate where slopes are less than 9 percent; severe where slopes are more than 9 percent: very slow permeability.
Slow permeability; suitable sites unlikely.	Fair stability; high shrink-swell potential; high compressibility; difficult to compact.	Slow permeability.	Features favorable in topsoil; cuts should be held to a minimum because of clayey subsoil.	Features favorable except where topsoil is removed exposing clayey subsoil.		Severe limitations; slow permeability; seasonal high water table.	Moderate: slopes 2 to 9 percent.
Nearly level; slow compacted permeability.	Fair stability; semiimpervious to impervious when compacted; poor compaction; high shrink-swell potential.	Slow or very slow permeability; some depressional areas need surface drains in addition to tile.	Nearly level	Nearly level		Severe: seasonal high water table; slow to very slow	Slight: slow or very slow permeability.
Slow compacted permeability; poor compaction.	Poor stability when wet; poor compaction; high compressibility.	Moderately well drained.	Soil features favorable.	Soil features favorable.		Moderate: moderately slow permeability.	Moderate where slopes are less than 9 percent, severe where slopes are more than 9 percent: moderately slow permeability.
Suitable sites unlikely; dugouts possible; slow permeability when compacted; subject to flooding; underlain by stratified material at depth of 5 feet or more.	Fair stability; slow permeability; high shrink-swell potential; high compressibility.	Protection from stream over flow needed; tile does not drain all areas satisfactorily; use surface drains in depressional areas; outlets difficult to establish in some places.	Clayey subsoil; terraces not needed; properly placed diversions can help to reduce local ponding and to improve drainage.	Nearly level		Severe: subject to flooding; high water table; very slow permeability.	Moderate or severe: subject to flooding; high in content of organic matter.
Suitable sites unlikely; poor compaction; underlain in places by stratified sandy material below a depth of 6 feet.	Poor stability; poor compaction; high in content of organic matter; high compressibility.	Moderately well drained to well drained.	Soil features favorable; diversions help to protect from local overflow.	Nearly level		Severe: subject to flooding.	Severe: moderate permeability; subject to flooding.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Judson: 8B, 8C	Good: thick layer high in content of organic matter.	Unsuitable	Unsuitable	Poor: high in content of organic matter in upper 2 to 3 feet; low or medium bearing capacity; difficult to compact.	Subject to flooding by local runoff in places; seepy in some places; low value as potential source of borrow; high in content of organic matter; nearly level to gently sloping.	High compressibility; low or medium bearing capacity and shear strength; subject to local runoff from higher elevations.
Kennebec: 212	Good: thick layer high in content of organic matter.	Unsuitable	Unsuitable	Poor: low bearing capacity; high in compressibility; high in content of organic matter.	Subject to flooding; high in content of organic matter; poor foundation for high fills.	High compressibility; low bearing capacity; subject to flooding.
Keswick. Mapped only in a complex with Lindley soils.	Fair in surface layer, poor below; low fertility; high content of clay in subsoil.	Unsuitable	Unsuitable	Very poor in upper 4 feet; good in substratum: elastic; high shrink-swell potential; highly dense material; good workability and compaction in substratum.	Strongly sloping to moderately steep; seepage in some cuts; highly susceptible to frost action when sand pockets occur; difficult to establish vegetative cover on slopes.	Low compressibility; high bearing capacity below depth of 4 feet; highly expansive if subject to wide fluctuations in moisture.
Ladoga: 76B, 76C, 76C2, 76D, 76D2, T76B, T76C2.	Good in surface layer, fair below: thin layer with organic matter.	Unsuitable	Unsuitable	Poor: medium bearing capacity and shear strength; moderate to high shrink-swell potential; difficult to compact.	Gently to strongly sloping; high in content of moisture in some deep cuts; low value as potential source of borrow.	Medium bearing capacity and shear strength; moderate compressibility; uniform consolidation.
Lamoni: 822C2, 822D2.	Fair in upper 10 inches, poor below; high in content of clay; low fertility.	Unsuitable	Unsuitable	Poor: difficult to compact; high shrink-swell potential.	Moderately to strongly sloping; often high in content of moisture in cuts; poor value as potential source of borrow.	High shrink-swell potential; fair bearing capacity; possible uneven consolidation.

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Difficult to compact; moderate permeability when uncompacted.	Fair stability; high compressibility; moderate shrink-swell potential; difficult to compact.	Moderate permeability; most areas do not need tile drains; interceptor tile needed in some seepy areas.	Soil features favorable; terraces generally not needed; diversions help to protect from local overflow.	Soil features favorable; tile helpful in controlling seepage in places.	Moderate: periodic overflow can cause damage to filter field.	Moderate: moderate permeability; high in content of organic matter.
Suitable sites unlikely; poor compaction; underlain in places by stratified sandy material below depth of 6 feet.	Poor stability; poor compaction; high in content of organic matter.	Moderately well drained; seasonal high water table.	Nearly level bottom land.	Nearly level bottom land.	Severe: occasional high water table; subject to flooding.	Severe: subject to flooding; high in content of organic matter.
Slow permeability; low seepage.	Fair to good stability; high shirnk-swell potential; good compaction; low compressibility; good for core material.	Wet because of seepage; interceptor tile needed at loess-till contact line.	Subsoil unfavorable for crop growth; terrace channel wet and seepy in places; cuts need to be held to a minimum.	Seasonally wet and seepy; tile needed to controll seepage and to establish vegetation; dense; low fertility in subsoil.	Severe: slow permeability; seasonally wet and seepy.	Severe: slopes more than 9 percent.
Uniform material; slow permeability when compacted; soil on benches underlain with stratified material at depth of 6 to 12 feet in places; deep cuts on benches can have low water holding potential.	Poor stability when wet; poor compaction; slow permeability when compacted; moderate to high shrink-swell potential.	Moderately well drained.	Soil features favorable.	Soil properties favorable.	Moderate: moderately slow permeability.	Moderate where slopes are less than 9 percent; severe where slopes are more than 9 percent: moderately slow permeability.
Very slow permeability when compacted.	Fair stability on flat slopes; impervious when compacted; suitable for cores; high expansion potential.	Wetness due to seepage; properly placed interceptor tile needed to control seepage in some areas.	Very low fertility in subsoil; subsoil difficult to vegetate.	Difficult to vegetate where subsoil is exposed; topdressing needed in most places.	Severe: very slow permeability; seasonally seepy and wet.	Moderate where slopes are less than 9 percent, severe where slopes are more than 9 percent: very slow permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Landes: 208	Fair: low available water capacity.	Fair: mostly poorly graded fine sand.	Unsuitable	Good: little or no volume change; good workability and compaction except where fines are less than 15 percent of soil; lacks stability in substratum except when damp.	Nearly level; high in content of moisture; good value as potential source of borrow; highly erodible where exposed in embankments; loose sand can hinder hauling operations.	Low compressibility; low shrink-swell potential; good shear strength; can liquefy if excavated when saturated.
Lindley: 65D2, 65E2, 65F2, 424D2, 424E2. For interpretations of the Keswick soil in mapping units 424D2 and 424E2, refer to the Keswick series.	Fair in surface layer, poor in subsoil: low fertility; high density in subsoil.	Unsuitable	Unsuitable	Good: medium to high bearing capacity; low compressibility; easily compacted; moderate shrink-swell potential.	Strongly sloping to steep; good source of borrow; some cuts seepy in places; low in content or organic matter in surface layer.	Medium to high bearing capacity and shear strength; low compressibility; possible uneven consolidation.
Mahaska: 280, 280B, T280.	Good: high in content of organic matter in surface layer.	Unsuitable	Unsuitable	Poor: low bearing capacity; high shrink-swell potential; difficult to compact; seasonal high water table.	Nearly level or gently sloping; high in content of organic matter in upper part; seasonal high water table; low value as potential source of borrow.	High compressibility; uniform consolidation; low bearing capacity and shear strength; expansive if subject to wide fluctuations in moisture content.
Marsh: 354	Poor: water present most of the time.	Unsuitable	Unsuitable	Unsuitable: standing water present in most places; highly organic material.	Water present most of the time.	Depressions with water present most of the time.
Mine pits and dumps: 502. Properties too variant to interpret.						
Nevin: 88	Good in surface layer, fair in subsoil: high in content of organic matter.	Unsuitable	Unsuitable	Poor: poor compaction; low bearing capacity; high in content of organic matter.	Nearly level; seasonal high water table; low value as potential source of borrow.	Medium to high compressibility; low bearing capacity; seasonal high water table; saturation can cause soil to settle; can liquify when wet.

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Material too porous to hold water.	Fair stability; low shrink-swell potential; susceptible to piping; difficult to vegetate embankments; highly erodible.	Well drained	Nearly level bottom land.	Nearly level bottom land.	Severe: substratum is poor filtering material and allows unfiltered sewage to travel long distances; subject to flooding.	Severe: moderately rapid to rapid permeability.
Slow permeability when compacted; good sites likely.	Good stability; easily compacted to high density; usable for cores; slow permeability when compacted; good workability.	Well or moderately well drained; interceptor tile can be useful if placed at the loess-till contact line to control seepy spots.	Slopes irregular and steep; subsoil low in fertility in many places.	Difficult to vegetate; tile needed to control seepage in places.	Severe: moderately slow permeability in subsoil.	Severe: slopes more than 9 percent.
Suitable sites unlikely; slow permeability when compacted; uniform material; sites on benches underlain with stratified materials at depth of 10 to 15 feet in places; deep cuts on benches may not hold water.	Fair stability; high shrink-swell potential; poor compaction; high compressibility.	Moderately slow permeability; seasonal high water table; tile drains satisfactory; not all areas need tile.	Soil features favorable.	Soil features favorable.	Moderate or severe: seasonal high water table; moderately slow permeability.	Slight where slopes are less than 2 percent, moderate where slopes are more than 2 percent: moderately slow permeability.
Suitable site unlikely; suited for dugout pond in places.	Water present in most places; poor embankment foundation.	Water present in most places; outlets seldom available.	Depressions with water present most of the time.	Depressions with water present most of the time.	Severe: water present most of the time.	Severe: water present most of the time.
Poor compaction; in places stratified below depth of 4 feet or more with coarse, porous material present; suitable sites unlikely.	Fair stability; medium to high compressibility; moderate to high shrink-swell potential; poor compaction.	Moderate or moderately slow permeability; seasonal high water table; tile drains work satisfactorily; not all areas require tile.	Features favorable; terraces not needed; properly placed diversions can help control runoff from uplands and reduce wetness in some places.	Generally not needed because of topography.	Moderate to severe: moderate to moderately slow permeability; seasonal high water table.	Slight to moderate: moderate to moderately slow permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Nira: 570B, 570C, 570C2.	Good in surface layer, fair in subsoil: medium in content of organic matter in surface layer.	Unsuitable	Unsuitable	Poor: very low bearing capacity when wet; difficult to compact; moderate or high shrink-swell potential.	Gently to moderately sloping; low value as potential source of borrow; cuts often have high moisture content.	High compressibility; subject to frost heave and subsequent loss of strength on thawing; can flow if excavated when saturated.
*Nodaway: 13B, 220, C220, 315. For interpretations of Vesser soil in mapping unit 13B and Alluvial land in mapping unit 315, refer to the Vesser series and Alluvial land, respectively.	Good: medium textured; low to medium in content of organic matter.	Unsuitable	Unsuitable	Poor: low bearing capacity when wet; moderate shrink-swell potential; difficult to compact.	Nearly level; subject to overflow; seasonal high water table; poor foundation for high fills.	High compressibility; subject to flooding; low bearing capacity.
Olmitz: 273B, 273C.	Good: thick layer high in content of organic matter.	Unsuitable	Unsuitable	Poor: high in content of organic matter to depth of 2 to 3 feet; medium to low bearing capacity; moderate shrink-swell potential.	Gently or moderately sloping; high in content of organic matter to depth of 2 to 3 feet; poor source of embankment material; subject to flash floods.	Medium to low bearing capacity; fair shear strength; medium compressibility; moderate shrink-swell potential; deep cuts seepy in places.
Ossian: 489	Good: seasonal high water table; high in content of organic matter.	Unsuitable	Unsuitable	Poor or very poor: low bearing capacity when wet; high in content of organic matter.	Nearly level; seasonal high water table; subject to flooding.	Flooding likely; high compressibility; low bearing capacity.
Otley: 281B, 281C, 281C2, 281D, 281D2, T281B, T281C2.	Good to fair: moderately fine textured.	Unsuitable	Unsuitable	Poor: low bearing capacity; difficult to compact; moderate or high shrink-swell potential.	Gently to strongly sloping; surface layer moderate in content of organic matter; high in content of moisture in some deep cuts; cuts easily vegetated.	Moderate compressibility; low uniform consolidation; low bearing capacity; expansive if subject to wide fluctuations in content of moisture.
Pershing: 131B, 131C2.	Fair in upper 1 to 1½ feet; poor below: clayey subsoil.	Unsuitable	Unsuitable	Very poor: high shrink-swell potential; low bearing capacity when wet.	Gently to moderately sloping: low value as potential source of borrow; high content of moisture can be expected in some cuts.	High compressibility; high shrink-swell potential; low bearing capacity when wet.

properties of the soils—Continued

Soil features affecting—Continued						Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Commonly occupy too high positions on landscape for suitable sites; slow permeability when compacted.	Poor stability when wet; poor workability; high compressibility.	Moderately slow permeability; wetness due to seepage; properly placed interceptor tile needed to control seepage; tile not needed in places.	Soil properties favorable; terraces can increase seepage unless carefully placed and constructed.	Soil features favorable; tile drainage needed in places to control seepage.	Slight to moderate: moderately slow permeability.	Moderate: slopes 2 to 9 percent.
Nearly level; good sites unlikely; some seepage.	Poor stability; poor compaction; poor resistance to piping; moderate shrink-swell potential.	Moderate permeability; subject to overflow.	Nearly level; diversions can help reduce runoff from uplands and reduce wetness in some places.	Soil properties favorable.	Severe: subject to frequent flooding.	Severe: subject to flooding; moderate permeability.
Only a few areas can be used for reservoirs because of position of landscape; slow permeability when compacted.	High in content of organic matter to a depth of 2 or 3 feet; fair stability; fair to poor workability and compaction; medium to high compressibility.	Well drained to moderately well drained.	Soil features favorable; diversions placed upslope protect soil from local runoff.	Soil features favorable.	Moderate: moderate or moderately slow permeability; periodic overflow can cause damage to filter fields.	Moderate: moderate or moderately slow permeability.
Good sites unlikely; nearly level; fluctuating high water table.	Poor stability when wet; high compressibility; poor compaction characteristics; poor resistance to piping.	Moderate permeability; subject to flooding; seasonal high water table.	Soil features favorable; properly placed diversions to control local runoff reduce wetness in some areas.	Nearly level	Severe: seasonal high water table; subject to flooding, especially in spring.	Severe: seasonal high subject to flooding.
Uniform material to a depth of 6 to 12 feet; slow permeability when compacted.	Fair stability; poor compaction; moderate to high shrink-swell potential.	Moderately well drained.	Soil features favorable.	Soil features favorable; vegetation easily established.	Slight to moderate; moderately slow permeability.	Moderate where slopes are less than 9 percent, severe where slopes are more than 9 percent.
Slow permeability.	Fair stability; poor compaction; high shrink-swell potential.	Clayey subsoil; slow permeability.	Clayey subsoil; vegetation difficult to establish where topsoil is removed.	Vegetation difficult to establish where deep cuts expose subsoil.	Severe: slow permeability.	Moderate where slopes are less than 9 percent, severe where slopes are more than 9 percent: slow permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Radford: 467	Good in upper 2 feet, fair below; high in content or organic matter; medium textured.	Unsuitable	Unsuitable	Very poor: low bearing capacity; difficult to compact; seasonal high water table; high compressibility; high in content of organic matter.	Nearly level: subject to overflow; poor foundation for high fills.	High compressibility; subject to flooding; low bearing capacity; uneven consolidation.
Riverwash: 53	Poor: mainly sandy and gravelly material.	Variable: check each site.	Poor	Variable: check each site.	Nearly level: subject to frequent overflow; frequent high water table.	Subject to frequent flooding; frequent high water table.
Rubio: 74	Fair or good in upper 16 inches, poor below: high in content of clay.	Unsuitable	Unsuitable	Very poor: medium bearing capacity; seasonal high water table; high shrink-swell potential.	Level: low value as potential source of borrow; seasonal high water table; subject to ponding.	Low bearing capacity; seasonal high water table; high shrink-swell potential.
Seaton: 663D2, 663E2, 663F2.	Fair to good: low in content of organic matter.	Unsuitable	Unsuitable	Fair to poor: medium or high compressibility; difficult to compact.	Strongly sloping to moderately steep: low value as potential source of borrow.	Medium to high compressibility; medium bearing capacity; medium shear strength.
Shelby: 24D2, 24E2.	Fair in surface layer, poor below: thin layer high in content of organic matter.	Unsuitable	Unsuitable	Good: medium to high bearing capacity; slight compressibility; good workability and compaction.	Strongly sloping to moderately steep; some deep cuts may be seepy; good potential source of borrow.	High bearing capacity; high shear strength; low compressibility; possible uneven consolidation.
Sogn: 412G	Very poor: shallow to bedrock.	Unsuitable	Unsuitable	Excellent in substratum; limestone bedrock; costly excavation.	Steep: cuts and fills needed; limestone hard and level-bedded.	Bedrock at depth of less than 20 inches.
Sparta: 41C, 442C2, 442D2. For interpretations of Otley soils in mapping units 442C2 and 442D2, refer to the Otley series.	Poor: very low available water capacity.	Good to fair: poorly graded fine sand.	Unsuitable	Good: low shrink-swell potential; erosive; lacks stability under wheel loads when dry.	Moderately to strongly sloping; highly erodible; seepage possible in some deep cuts; difficult to vegetate; loose sand can hinder hauling operations; good potential source of borrow.	Low compressibility; good shear strength and bearing capacity; low volume change on wetting; can liquefy during excavation and slump if wet.

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Compaction difficult; some seepage can be expected; difficult to compact.	Fair to poor stability in upper 2 feet when moisture content is high, very poor stability in lower part; poor compaction; moderate or high shrink-swell potential.	Moderate permeability; subject to flooding.	Nearly level: soil features favorable for diversions.	Nearly level soil: soil features favorable.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table; high in content of organic matter.
Mainly sandy and gravelly material near streams; rapid permeability.	Subject to frequent overflow; frequent high table; mainly sandy and gravelly material near streams.	Subject to flooding; frequent high water table.	Nearly level land near streams.	Nearly level land near streams.	Severe: subject to frequent flooding; frequent high water table.	Very severe: very porous sandy and gravelly material near streams subject to frequent flooding; frequent high water table.
Suitable sites unlikely; slow or very slow permeability.	Poor stability when wet; difficult to compact; high shrink-swell potential.	Slow or very slow permeability; tile may not drain all areas; surface drainage needed to remove ponded water.	Nearly level	Nearly level	Severe: slow or very slow permeability; seasonal high water table.	Slight to moderate; seasonal high water table; slow or very slow permeability.
Permeable subsoils can cause excess seepage; uniform material.	Fair stability; medium to high compressibility; narrow moisture range for optimum compaction; poor resistance to piping.	Well drained; strongly sloping to steep.	Soil features favorable; severe to moderate erosion hazard.	Soil features favorable; severe to moderate erosion hazard.	Severe: slopes more than 9 percent.	Severe: slopes more than 9 percent.
Moderately slow permeability; good sites common; sand pockets and stones in a few places.	Adequate stability; easily compacted to high density; good workability; suitable for cores.	Moderately well drained; interceptor tile upslope may help to control seepage at the loess-till contact line.	High density subsoil backslopes and channels difficult to vegetate in places.	Seepage on sides of waterways in places.	Severe: moderately slow permeability.	Severe: slopes more than 9 percent.
Fractured limestone at depth of less than 20 inches.	Bedrock at depth of less than 20 inches.	Somewhat excessively drained; limestone bedrock at depth of less than 20 inches.	Limestone bedrock at depth of less than 20 inches; steep.	Limestone bedrock at depth of less than 20 inches; steep.	Very severe: shallow depth to fractured limestone.	Very severe: shallow to fractured limestone.
Very rapid permeability; material too porous to hold water.	High seepage: highly erodible; low shrink-swell potential; poor resistance to piping.	Excessively drained.	Highly erodible; difficult to build and maintain terrace ridges and channels; vegetative cover difficult to establish where subsoil is exposed.	Highly erodible: very low available water capacity; difficult to vegetate.	Slight: very rapid permeability; severe danger of contamination of wells or streams.	Severe: very rapid permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Sperry: 122	Fair in surface layer, poor below: subsoil high in content of clay.	Unsuitable	Unsuitable	Very poor: low bearing capacity; high shrink-swell potential; difficult to compact.	Depressional; high water table; moderately high in content of organic matter in surface layer; low value as potential source of borrow.	Low bearing capacity; high compressibility; high water table.
Spillville: 485	Good: thick layer high in content in organic matter.	Unsuitable	Unsuitable	Poor: high in content of organic matter; fair bearing capacity; high compressibility.	Nearly level; subject to flooding; poor foundation for high fills.	Fair bearing capacity; fair shear strength; occasional high water table; subject to flooding.
Spillville loam, sandy substratum: 270.	Good to 40 inches, poor below; high in content of sand.	Unsuited in upper 40 to 50 inches, fair to poor below.	Unsuitable	Fair: high in content of organic matter to depth of 2 feet; medium bearing capacity; high compressibility.	Nearly level; subject to flooding; sand at depth of about 40 to 50 inches.	Medium bearing capacity; fair shear strength; occasional high water table; subject to flooding.
Taintor: 279, T279.	Fair: high in content of organic matter; high in content of clay.	Unsuitable	Unsuitable	Very poor elastic; medium bearing capacity; poor shear strength; high shrink-swell potential; difficult to compact.	Nearly level; high in content of organic matter in upper 1 to 2 feet; seasonal high water table; low value as potential source of borrow.	Medium compressibility; medium bearing capacity; uniform consolidation; high shrink-swell potential.
Tuskeego: 453	Fair in surface layer, poor in clayey subsoil.	Unsuitable	Unsuitable	Very poor: highly elastic; low bearing capacity; difficult to compact; high shrink-swell potential.	Level: low value as potential source of borrow; seasonal high water table; subject to ponding; areas generally small.	Low bearing capacity; low shear strength; seasonal high water table.
Vesser: 51, 51B	Good to fair: seasonal high water table.	Unsuitable	Unsuitable	Fair to poor: low bearing capacity; moderate to high shrink-swell potential; difficult to compact to high density.	Nearly level: subject to flooding; seasonal high water table; low value as potential source of borrow; surface layer high in content of organic matter; poor foundation for high fills.	High compressibility; subject to short floods; seasonal high water table; uneven consolidation.

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Suitable areas unlikely; slow permeability when compacted; on high upland divides.	Poor stability when wet; moderate to high shrink-swell potential; poor workability; high compressibility.	Subject to ponding; very slow to slow permeability; tile may not drain all areas; surface drains needed to remove ponded water.	Depressional areas.	Depressional areas.	Severe: high water table; slow to very slow permeability.	Moderate: slow or very slow permeability.
Subject to flooding; moderate permeability; coarse textured, porous substratum in places; high in content of organic matter.	Fair stability; fair compaction below a depth of 3 feet; poor embankment foundation.	Subject to flooding; moderate permeability; moderately well drained and somewhat poorly drained.	Soil features favorable; nearly level topography; properly placed diversions can help to control runoff from uplands and reduce flooding in some places.	Soil features favorable; nearly level.	Severe: subject to flooding and seasonal high water table.	Severe: high in content of organic matter; subject to flooding.
Rapid permeability in sand at depth of 40 to 50 inches; high seepage potential.	Fair stability; fair compaction in upper part; sand susceptible to piping; erodible.	Subject to flooding; tile or surface drainage suitable but not generally needed.	Soil features favorable; nearly level; diversions properly installed help to protect from local runoff in places.	Soil features favorable; nearly level.	Severe: subject to flooding; rapidly permeable substratum can cause downstream seepage and water pollution.	Severe: subject to flooding; rapidly permeable substratum can cause downstream seepage and water pollution.
Suitable sites unlikely; slow permeability; areas on benches are underlain with stratified material.	Fair stability; poor compaction; high shrink-swell potential; poor workability above optimum moisture level.	Seasonal high water table; tile drains satisfactory if properly spaced.	Nearly level	Nearly level	Severe: seasonal high water table; moderately slow permeability.	Moderate: high in content of organic matter; seasonal high water table.
Very slow permeability; underlain in places with stratified material at depth of 5 feet or below; suitable for dugout ponds in places.	Poor stability when wet; impervious; moderate to high compressibility; high shrink-swell potential.	Very slow permeability; tile lines may not drain all areas; surface drainage needed to remove ponded water.	Nearly level to depressional: diversions properly placed upslope help to control local runoff and reduce wetness.	Nearly level to depressional.	Severe: seasonal high water table; very slow permeability.	Severe: subject to flooding.
Slow permeability when compacted; good sites unlikely; some areas satisfactory for dugout ponds in places; underlain in places with stratified material at depth of 5 feet or below.	Fair to poor stability; moderate to high shrink-swell potential; poor compaction when wet; some areas susceptible to piping.	Seasonal high water table; tile drains satisfactory where outlets can be obtained.	Terraces not needed; diversions properly placed are beneficial in preventing local runoff and siltation.	Nearly level to gently sloping; tile needed alongside drainageways to prevent seepage.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; high seepage rate.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings
Watkins: 687, 687B.	Good in surface layer, fair to good below.	Unsuitable	Unsuitable	Poor: moderate or high shrink-swell potential; medium bearing capacity; difficult to compact to high density.	Nearly level to gently sloping: low value as potential source of borrow; surface layer high in content of organic matter.	Moderate or high compressibility; medium bearing capacity.
Weller: 132C2	Good to fair in surface layer, poor below: clayey subsoil.	Unsuitable	Unsuitable	Very poor: moderate or high shrink-swell potential; low bearing capacity when wet.	Low value as potential source of borrow; high content of moisture can be expected in cuts.	Moderate compressibility; expansive if wide fluctuations in content of moisture; low bearing capacity when wet.
Wiota: 7	Good: medium textured surface layer.	Unsuitable	Unsuitable	Poor to fair: moderate to high shrink-swell potential; medium bearing capacity.	Nearly level: low value as potential source of borrow; high in content of organic matter.	High compressibility; medium bearing capacity; high expansion potential with changes in content of moisture.
Zook: 54+, 54, 54B, 248.	Poor: high in content of clay.	Unsuitable	Unsuitable	Very poor: extremely high volume change; low bearing capacity; highly elastic; difficult to compact properly.	Level to depressional; surface layer high in content of organic matter; high water table; low value as potential source of borrow; poor foundation for high fills.	Low bearing capacity; low shear strength; medium to high compressibility; high water table; subject to dangerous shrinkage on drying.

Moines and Skunk Rivers and their tributaries. The limestone is crushed and used to surface the secondary roads throughout the county.

Formation and Classification of Soils

This section presents the outstanding morphological characteristics of the soils of Mahaska County and relates them to the factors of soil formation. The system of soil classification now in use is explained, and the soil series are classified.

Factors of Soil Formation

Soil is produced when soil-forming processes act on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the *parent material*, the *climate* under which the soil material has accumulated and existed since accumulation, the *plant and animal life* on and in the soil, the *relief* or lay of the land, and the length of *time* the forces of soil development have acted on the soil material.

Climate and vegetation, chiefly vegetation, are active factors in soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme instances, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Usually, a long time is required for the development of distinct horizons.

These five factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can

properties of the soils—Continued

Soil features affecting—Continued					Degree and kind of limitation for—	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Septic tank disposal fields	Sewage lagoons
Reservoir area	Embankment					
Suitable sites unlikely; some areas too porous in substratum.	Loss of stability when wet; very narrow range of moisture content for compaction; high compressibility; poor resistance to piping.	Well drained and moderately well drained; drainage not needed in most places.	Soil features favorable; diversions properly placed help control runoff from the uplands and are beneficial in some places.	Soil features favorable.	Moderate: moderate permeability.	Moderate: moderate permeability.
Slow permeability; suitable sites likely.	Moderate or high shrink-swell potential; fair stability.	Clayey subsoil; slow permeability.	Clayey subsoil; vegetation difficult to establish where topsoil is removed.	Clayey subsoil; vegetation difficult to establish where topsoil is removed.	Severe: slow permeability.	Moderate: slopes more than 5 percent.
Suitable sites unlikely; moderate permeability.	Fair stability; moderate to high potential; high shrink-swell compressibility.	Well drained and moderately well drained; agricultural drainage not needed.	Soil features favorable; diversions properly placed upslope help protect areas from runoff from uplands.	Soil features favorable; nearly level.	Slight: moderate permeability.	Moderate: moderate permeability.
Subject to flooding; high in content of organic matter in upper 3 feet.	Fair stability; poor compaction; high shrink-swell potential; high in content of organic matter in upper 3 feet.	Slow permeability; tile drains poor to satisfactory; outlets difficult to obtain in some places.	Nearly level; properly placed diversions needed to control local runoff and reduce wetness in some areas.	Nearly level	Severe: subject to flooding; slow permeability; seasonal high water table.	Severe: seasonal high water table; subject to flooding.

be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are not fully known.

Parent material

Most of the soils in Mahaska County have developed in glacial till, loess, or alluvium. Local loess and eolian sands are of minor importance along the Skunk and Des Moines Rivers. A few soils formed in limestone, sandstone, or shale bedrock.

Glacial till.—The major Pleistocene deposits of pre-Wisconsin age in the county are Nebraskan and Kansan drift (*11, 12*). The Nebraskan drift is exposed only in some of the steeper, more dissected areas of the county. The Kansan drift is identifiable throughout the county, and on steep slopes it forms an extensive part of the landscape (*7*). Glacial till consists of coarse fragments in a loam and clay loam matrix. The steeper soils in the county formed from till that is leached and oxidized to a depth of 3 to 6 feet. Below this is a layer of unleached oxidized till several feet thick. It grades to unleached glacial till that has not been oxidized. These strata can be seen in many deep road cuts in the county.

Soils developed on the Kansan till plain during the Yarmouth and Sangamon interglacial ages. This was before the loess was deposited. In nearly level areas, beveling was slight. Beveling is the planing by geologic erosion of the outcropping edges of strata. In time the soils were strongly weathered and had formed a gray, clayey subsoil called gumbotil (*3, 4*). It is several feet thick on stable divides and is very slowly permeable. A widespread erosion surface was cut below the Yarmough-Sangamon paleosol into Kansan till and older deposits. This surface generally is characterized by a stone line or underlying sediment and is overlain by pedisediment (*7, 8*). A paleosol formed in the pedisediment stone line and in the underlying till.

Geologic erosion has removed the loess from many slopes and has exposed the strongly weathered paleosols. In some places the paleosols have been beveled or truncated, and only the lower part of the strongly weathered material remains. In

TABLE 5.—*Engineering*

Soil name and location	Parent material	Report No. AADO	Depth	Moisture density[1]		Mechanical analysis[2]—		
				Maximum dry density	Optimum moisture	Percentage passing sieve— ¾ in	⅜ in	No. 4 (4.7 mm)
			Inches	*Percent*	*Percent*			
Flagler fine sandy loam: 155 feet east and 600 feet north of southwest corner of NW¼ SW¼, section 31, T. 74 N., R. 15 W. (Modal).	Stratified alluvium.	11028	0–22	114	14	----------	----------	----------
		11029	22–33	121	13	----------	----------	----------
		11030	36–60	120	11	100	98	95
Hedrick silt loam: 570 feet north and 440 feet west of southeast corner of SW¼, section 30, T. 77 N., R. 17 W. (Modal).	Loess.	11031	0–8	102	20	----------	----------	----------
		11032	8–15	96	23	----------	----------	----------
		11033	36–60	100	20	----------	----------	----------

[1] Based on AASHO Designation T 99-57, Method A (*1*).

[2] Mechanical analyses according to the AASHO (*1*) Designation T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser

other places erosion has removed all of the paleosol and has exposed till that is only slightly weathered.

The Clarinda soils formed where the strongly weathered gray paleosols crop out. The Lamoni soils formed where the paleosols are partly truncated. Where the less strongly reddish paleosols crop out, the Armstrong and Keswick soils formed. The Shelby, Gara, and Lindley soils formed on slightly weathered Kansan till. These soils, the youngest on glacial till in Mahaska County, developed after loess was deposited during the Late Wisconsin time (*7*).

The deoxidized and leached weathering zone over the Yarmouth-Sangamon paleosol occurs throughout Mahaska County, except where the loess is very thin or absent on steep side slopes. The deoxidized and leached zone is related to the paleosol and is not necessarily related to the thickness of the loess. The surface layer and subsoil of the Otley, Ladoga, and Clinton soils developed predominantly from oxidized and leached loess. The Nira soils formed mainly from deoxidized and leached loess.

Alluvium.—Alluvium consists of sediment that has been removed and laid down by water. As it moves, the sediment is sorted to some extent, but it is as well sorted as loess in only a few places. Also, alluvium does not have the wide range of particle sizes that occurs in glacial drift. Alluvium is silt and clay, silt and sand, or sand and gravel. The coarse sand and gravel generally occur only in the pre-Sangamon alluvial sediment in high stream benches and, in most places in Mahaska County, are buried beneath several feet of loess. Because the alluvium in the county was derived from loess and glacial drift, it consists mostly of a mixture of silt and clay or silt and sand. Where sediment has accumulated at the foot of the slope on which it originated, the material is called local alluvium. Alluvial sediment is the parent material of the soils on flood plains, on terraces, and along drainageways.

Loess.—Loess of Wisconsin age covers much of Mahaska County, particularly on the most stable landscape, and is the most extensive parent material in the county. The loess ranges from about 12 to 14 feet in thickness on the stable upland divides, but it is thinner on the steeper side slopes (*6*). It consists of accumulated particles of silt and clay that have been deposited by wind. Variations in the soils are related to their distance from the source of loess.

On a loess-covered divide, the Sperry, Taintor, Givin, and Rubio soils were formed. The Mahaska soils may have developed from both oxidized loess and deoxidized loess, because iron segregations and gray colors can be traced into a browner upper part of the profile. Similar iron segregations and gray colors merge with the gleyed upper part of the profile in Taintor and Sperry soils. It is theorized that the loess was deoxidized before the soils formed, and the weathering zones (fig. 30) represent differences in parent material.[6]

In the more sloping soils on convex slopes of the upland divides, the upper part of the loess was oxidized and leached and the lower part was deoxidized and leached.

If a river overflows and water spreads over the flood plain, coarse-textured materials such as sand are deposited first. Sand commonly is deposited in low ridges, called natural levees, parallel to and near the channel. As the floodwater continues to spread, it moves more slowly and deposits the finer textured sediment such as silt. After the flood has passed, the finest particles, or the clay, settle from the water that is left standing in the lowest part of the flood plain.

This pattern of sedimentation can be seen on flood plains along the Des Moines and Skunk Rivers. Near the channels, or within the present meander belt, are recent alluvial soils, such as Flagler and Landes soils and the Nodaway-Alluvial land complex. Alluvial land consists of some sandbars next to the channel and of various amounts of sand, silt, and clay. The Flagler and Landes soils are moderately coarse textured. The Nodaway soils consist mainly of stratified silt material.

[6] R. I. DIDERIKSEN, Master of Science thesis, "Soil-Landscape Relationships of the Mahaska Toposequence," Iowa State University, Ames, Iowa, 1966.

test data

Mechanical analysis[2]—Continued							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued			Percentage smaller than—							
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			AASHO[3]	Unified
							Percent			
100	84	46	44	33	19	15	25	7	A-4(2)	SM
100	76	38	35	25	17	14	23	7	A-4(1)	SM
91	59	12	10	9	7	6	19	2	A-2-4(0)	SM-SW
100	99	98	87	59	36	27	37	14	A-6(10)	CL or ML
----------	----------	99	95	71	47	40	47	24	A-7-6(15)	CL
----------	----------	99	92	63	39	33	45	25	A-7-6(15)	CL

than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[3] Based on AASHO Designation M 145-49.

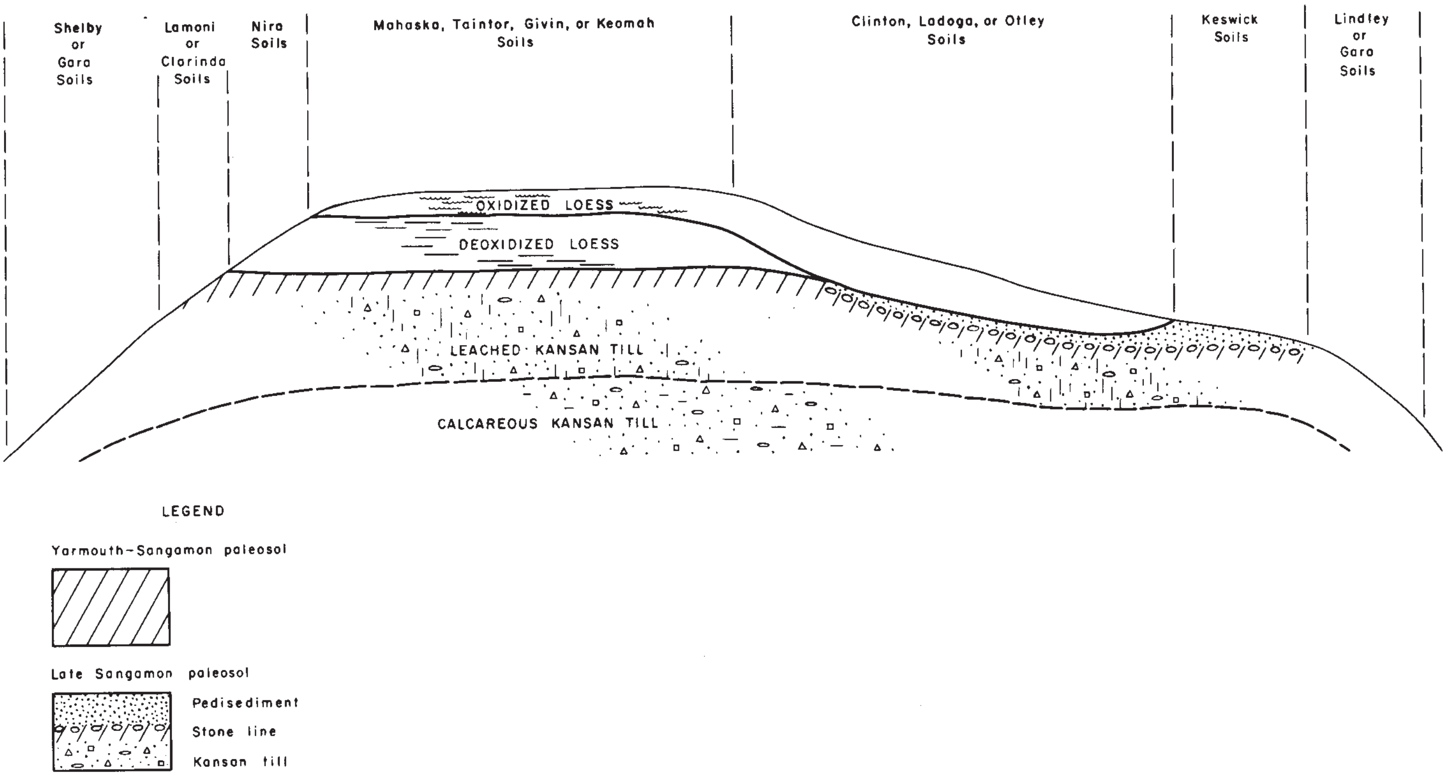

Figure 30.—**Cross section showing weathering zones in Wisconsin loess.**

Where floods do not spill over the natural levees, some finer textured material was deposited. On bottom lands, away from the meander belt, the Amana, Vesser, and similar soils developed. These soils consist mainly of silt and partly of sand and clay. Beyond these soils, as much as half a mile from the present channel, the finer textured Colo and Bremer soils occur. Farthest from the channel are the Zook and Humeston soils, which contain a higher percentage of clay than the Amana and Nodaway soils.

The Colo, Nodaway, and Radford soils occur along many of the smaller streams and upland drainageways throughout the county. Where the texture differs, so do the chemicals and minerals. Except for the medium acid to strongly acid Amana and Vesser soils, the soils are mostly free of carbonates and slightly acid.

The soils on terraces or second bottoms also consist of alluvium and vary in texture. The Tuskeego and Nevin soils are moderately fine textured. They developed in alluvium that contained little sand, but some of the benches are underlain with sand below a depth of 4 feet.

The Ely, Judson, and Olmitz are the principal soils that formed at the base of upland slopes or from local alluvium. They are widely distributed throughout the county and make up a large percentage of the soils formed in alluvium.

Eolian sand.—Wind-deposited sand is not extensive in Mahaska County. Deposits occur along the Des Moines and Skunk Rivers. Most of the deposits are immediately adjacent to these major streams on the south or east side of the channel. The Sparta and Chelsea soils developed in eolian sand and can be distinguished by their high content of fine and very fine sand and their low content of silt and clay.

Limestone bedrock.—Most of Mahaska County is underlain by limestone bedrock, but in most places it is covered to great depths by loess and glacial till. The only place that the limestone crops out is on steep slopes along the Des Moines and Skunk Rivers and their tributaries. The Sogn soils are shallow to limestone and make up a very small percentage of the county.

Sandstone bedrock.—The beds of sandstone are discontinuous across Mahaska County. These beds crop out from a few steep areas along the Des Moines and Skunk Rivers. Boone soils formed in material derived from sandstone.

Shale bedrock.—Shale is the parent material of the Gosport soils. Shale can be distinguished from the loess by its high content of clay and, when moist, by its soapy feel. The shale in the county contains thin lenses of sandstone, limestone, and in some areas, coal. The shale is exposed on steep slopes in the southwestern part of the county.

Climate

The soils of Mahaska County have been developing under a midcontinental climate. Summers are warm, occasionally dry, and windy, and winters are cold and dry (*5*). Rainfall is moderate. It is thought that the soils on nearly level upland areas of the county are about 14,000 to 16,000 years old (*9*) and that the climate was cool and moist from 25,000 to 5,000 years ago. From 5,000 years ago to the present time the climate was warmer and subhumid to humid.

The influence of the general climate of the county is modified by local conditions in or near the developing soil. For example, soils on south-facing slopes formed under a microclimate that is warmer and drier than the average climate of nearby areas. The depressions and wide divides have a high water table during part of the year, but available data indicate that the depth to the water table has changed. In his studies of the Mahaska toposequence, Dideriksen found that the downward movement of clay had been impeded by a water table that was higher or more permanent than the one that exists at present. This is supported by the fact that the poorly drained soils have a shallower depth to clay maximum than do the nearly level, moderately well drained soils.

Climate also is closely related to topography. As landscapes differ, the influence of climate on soil development changes.

Plant and animal life

Plant and animal life, especially plant life, are important factors in soil formation. Studies of groups of soils in eastern, central, and southern Iowa show that significant differences in soils were caused by variations in vegetation (*19*). Differences in soils in southeastern Iowa are reported to be related to vegetation and topography.[7] Studies of the soils in Mahaska County show that from 25,000 years ago to about 6,500 years ago the predominant vegetation was forest, and from 6,500 years ago to the present the climate favored prairie grasses (*9*, *11*, *18*).

Soil formation really begins with the coming of vegetation. Organic matter, or humus, imparts a dark color to the surface soil. Because grasses have many roots and tops that decay on or in the soil, soils formed under prairie vegetation have a thick, dark-colored surface layer. Prairie vegetation was dominant in Mahaska County on the undulating and gently rolling soils on broad uplands. In contrast, soils formed under trees have a thinner, lighter colored surface layer because the amount of organic matter, derived principally from leaves, is much less than that derived from tall prairie grasses. Forest vegetation dominates the broken uplands along the rivers and larger creeks throughout Mahaska County.

Evidence indicates that vegetation shifted during soil development in areas bordering the prairie and forest areas. The Givin, Ladoga, and Gara soils reflect the influence of both trees and grass.

Relief

Relief is an important cause of differences among soils. It indirectly influences soil development through its effect on drainage.

In Mahaska County, the relief ranges from broad, level upland divides and rolling to steep side slopes to broad, nearly level bottom lands. Because very little rainfall runs off, the broad upland divides have seasonal high water tables. The bottoms frequently are flooded and also have seasonal high water tables. On stronger slopes, much of the rainfall runs off. In Mahaska County, the percentage of clay is highest in depressional areas and lowest on side slopes; also, the greatest depth to maximum clay was below wide interfluves and the shallowest was in depressions. The ratio of clay in the subsoil to that in the surface layer is highest in soils in depressional areas and lowest on wide divides. Depth to the most acid part of the profile is shallowest in depressions and on wide divides, but there is little difference in depth on other landscape units.

On the Shelby, Gara, Lindley, and similar soils that have a wide range of slopes and landscapes, the depth to carbonates is shallower where slopes are the steepest and convex, or on the most unstable part of the landscape.

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[7] J. F. Corliss, doctorate thesis, "Genesis of Loess-derived soils in southeastern Iowa," Iowa State University, Ames, Iowa, 1958.

In places throughout Mahaska County, changes in topography have resulted in the exposure of weathered material. In the loess areas, deoxidized loess is exposed. The Nira soils developed from deoxidized and leached loess. At lower elevations, paleosols that formed from material laid down in the Yarmouth-Sangamon and Late Sangamon periods of glaciation are exposed. The Clarinda, Lamoni, Armstrong, and Keswick soils developed from these paleosols.

Time

The length of time required for a soil to develop affects the kind of soil that forms. An older or more strongly developed soil shows well-defined genetic horizons. A less well developed soil shows only weakly developed horizons.

No precise ages can be assigned to landscape surfaces in Mahaska County, but relative ages can be determined (*14*). If the major loess surface is 14,000 to 26,000 years old, the surface of the loess on wide divides is similar in age or younger. Side slopes that cut or bevel these wide divides must have a surface layer that is younger, or less than 16,000 years old. Since much or all of the alluvial sediment in the upland drainageways came from adjacent upland slopes, the maximum age of the side slopes in these drainageways should be the same as the lower increment of alluvial sediment in the valleys. The minimum age of the side slopes should equal the age of the surface of the alluvium. Applying this line of reasoning, the Otley and Nira soils are younger than the adjoining Taintor and Mahaska soils, and the Clinton and Ladoga soils are younger than the Givin and Rubio soi.ls

The Clarinda, Lamoni, and Keswick soils are among the oldest soils in the county (*9*). These soils formed from Kansan till that began to weather in Yarmouth-Sangamon and Late Sangamon time.

The Shelby, Lindley, and Gara soils formed from Kansan till that was exposed in the Wisconsin stage and in Recent time. These soils are younger than those on the stable upland because they are not mantled with loess. They are younger than or at least no older than the most stable Otley, Mahaska, Ladoga, Clinton, or Givin soils.

Man's influence on the soil

Important changes take place in the soil when it is cultivated. Some of these changes have little effect on soil productivity; others have drastic effect.

Changes caused by water erosion generally are the most apparent. On many of the cultivated soils in the county, particularly the gently rolling to hilly ones, part or all of the original surface has been lost through sheet erosion. In some places shallow to deep gullies have been formed.

In many continuously cultivated fields, the granular structure that was apparent when the grassland was undisturbed is no longer present. In these fields the surface layer tends to bake and harden when it dries. Fine-textured soils that have been plowed when too wet tend to puddle and are less permeable than similar soils in undisturbed areas.

Man has done much to increase productivity of the soil and to reclaim areas not suitable for crops. He has made large areas of bottom lands suitable for cultivation by digging drainage ditches and constructing diversions at the foot of slopes. Through the use of commercial fertilizers, man has counteracted deficiencies in plant nutrients and has made some soils more productive than they were in their natural state.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*13*). The system currently used by the National Cooperative Soil Survey was developed in the early sixties, and was adopted in 1965 (*16*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 6 shows the classification of each soil series of Mahaska County by family, subgroup, and order, according to the current system. The categories of the current system are briefly defined in the paragraphs that follow:

ORDERS. The ten soil orders recognized are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, the Entisols and Histosols, occur in many different climates.

The four orders found in Mahaska County are Inceptisols, Mollisols, Alfisols, and Entisols. Inceptisols, based on the Latin word *inceptum*, meaning beginning, are young soils in which genetic horizons definitely have started to form but in which eluviation and illuviation are not pronounced. The Gosport soils are the only Inceptisols in Mahaska County.

Mollisols have dark-colored surface horizons in which base saturation is high and the content of organic matter is at least 1 percent. These soils have genetic subsurface horizons that vary in degree of development. In Mahaska County this order includes soils previously classified as Brunizems, Humic Gleys, and Planosols.

Alfisols have clay-enriched B horizons that are high in base saturation. In Mahaska County, this order includes soils formerly classified as Gray-Brown Podozolic soils that intergrade to Brunizems.

Entisols do not have genetic horizons or have only the beginnings of such horizons. The surface layer of these soils is darkened by organic matter. The Entisols in Mahaska County were formerly classified as Alluvial soils.

SUBORDERS. Each order is subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of wetness, or soil differences resulting from climate or vegetation. The names of suborders have two syllables, and the last syllable indicates

TABLE 6.—*Soil series classified according to the current system of classification*

Series	Current system		
	Family	Subgroup	Order
Amana	Fine-silty, mixed, mesic	Aquic Hapludolls (Fluvaquentic)	Mollisols.
Armstrong	Fine, montmorillonitic, mesic	Aquollic Hapludalfs	Alfisols.
Boone[1]	Mesic uncoated	Typic Quartzipsamments	Entisols.
Bremer	Fine, montmorillonitic, mesic	Typic Argiaquolls (Cumulic Haplaquolls)	Mollisols.
Caleb	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Chelsea	Mixed, mesic	Alfic Udipsamments	Entisols.
Clarinda	Fine, montmorillonitic, mesic, sloping	Typic Argiaquolls	Mollisols.
Clearfield	Fine-silty, mixed, mesic, sloping	Typic Argiaquolls (Haplaquolls)	Mollisols.
Clinton	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Colo	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Downs	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Ely	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Fayette	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Flagler	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Gara	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Givin	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Gosport	Fine, illitic, mesic	Typic Dystrochrepts	Inceptisols.
Grundy[2]	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Haig	Fine, montmorillonitic, mesic	Typic Argiaquolls (Vertic)	Mollisols.
Hedrick	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Humeston	Fine, montmorillonitic, mesic	Argiaquic Argialbolls	Mollisols.
Huntsville	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Keswick	Fine, montmorillonitic, mesic	Aquic Hapludalfs	Alfisols.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Lamoni	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Landes[3]	Coarse-loamy, mixed, mesic	Fluventic Hapludolls	Mollisols.
Lindley	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Mahaska	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Nevin	Fine-silty, mixed, mesic	Aquic Argiudolls (Hapludolls)	Mollisols.
Nira	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Olmitz	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Ossian	Fine-silty, mixed, mesic	Typic Haplaquolls	Mollisols.
Otley	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Pershing	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Radford	Fine-silty, mixed, mesic	Fluventic Hapludolls (Fluvaquentic)	Mollisols.
Rubio	Fine, montmorillonitic mesic	Mollic Albaqualfs	Alfisols.
Seaton	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Sparta	Sandy, mixed, mesic	Entic Hapludolls	Mollisols.
Sperry	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Spillville	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Taintor	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Tuskeego	Fine, montmorillonitic, mesic	Mollic Ochraqualfs	Alfisols.
Vesser	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols.
Watkins	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Weller	Fine, montmorillonitic, mesic	Aquic Hapludalfs (Aeric Ochraqualfs)	Alfisols.
Wiota	Fine-silty, mixed, mesic	Typic Argiudolls (Cumulic Hapludolls)	Mollisols.
Zook	Fine, montmorillonitic, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.

[1] The Boone soils in Mahaska County are considered to be taxadjuncts to the Boone series because they are shallower to bedrock than the minimum limit in the defined range of the series.

[2] The Grundy soils in Mahaska County are considered to be taxadjuncts to the Grundy series because the clay content is less than the minimum limit in the defined range for the series.

[3] The Landes soils in Mahaska County are considered to be taxadjuncts to the Landes series because they have neutral reaction and lack free carbonates within depths of 40 inches or more.

the order. For example, in Udolls, *Ud* is from the Latin word meaning humid and *oll* is from Mollisol.

GREAT GROUPS. Soil suborders are separated into great groups on the basis of uniformity in kind and sequence of major soil horizons and features. The horizons used to make such separations are those in which clay, iron, or humus have accumulated or those in which pans interfere with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown in a separate column in table 6 because it is the last word in the name of the subgroup.

SUBGROUPS. Great groups are divided into subgroups, one representing the central (typic) segment of the group and the others, called intergrades, that have properties of the group

TABLE 7.—*Temperature and precipitation*

[Data recorded at Oskaloosa]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly highest maximum	Average monthly lowest minimum	Average monthly total	One year in 10 will have—		No. of days with 1 inch or more of snow	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F	°F	°F	°F	Inches	Inches	Inches		Inches
January	32	13	54	−13	1.2	0.4	2.6	17	4
February	35	16	55	−8	1.2	.3	2.1	12	4
March	47	27	72	4	2.1	.8	4.5	7	6
April	62	39	83	23	3.0	1.4	6.6	(1)	1
May	73	50	88	34	3.9	1.3	8.0	0	0
June	81	60	93	45	4.6	1.9	7.3	0	0
July	87	64	97	51	3.7	1.3	6.5	0	0
August	85	62	96	47	3.5	.8	6.9	0	0
September	78	54	92	34	3.5	.7	7.0	0	0
October	66	42	85	24	2.4	.3	5.0	(1)	2
November	49	29	71	10	1.9	.6	3.7	2	2
December	36	18	59	−6	1.3	.5	2.9	10	3
Annual	61	39	99	−16	32.0	25.9	43.8	48	4

[1] Less than half a day.

and also one or more properties of another great group, suborder, or order. Subgroups also may be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of the subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Hapludoll (a typical Hapludoll).

FAMILIES. Families are separated with a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for construction by engineers. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability. thickness of horizons, and consistence. A family name precedes the subgroup name and consists of a series of adjectives descriptive of these various properties. An example is the coarse-loamy, mixed, mesic family of Typic Hapludalfs.

General Nature of the County

The history, climate, relief, and drainage of Mahaska County are discussed briefly in this section. This information will be of special interest to those who are not familiar with the county.

History

The area that is now Mahaska County was originally inhabited by the Sac and Fox tribe of the Ioway Indians. The first white men settled there in 1843. Farms were staked at this time, and clearing and farming began.

In April 1844 the county was organized. Mahaska County was named after Chief Mahaska of the Sac and Fox tribe. Oskaloosa was designated as the county seat on May 11, 1844.

The Des Moines Valley Railroad reached Oskaloosa in 1864. Although Mahaska has always been primarily a farming county, coal mining then became the largest industry. By 1883 there were 38 mines in operation with an output of about 1 million tons annually. Mining activities were in the southwest quarter of the county and centered around the town of Beacon. Although coal mining operations were greatly reduced after the 1930's, they have continued. Mahaska County is one of the largest coal-producing counties in Iowa.

Industrial development around Oskaloosa is limited. The main industries are a foundry, a soft-drink manufacturing plant, and businesses that sell products and services used in farming. Educational facilities include William Penn College, which is located at Oskaloosa.

Before tile drainage became accepted, most level land was left in grass because of its wet condition. After tile drainage became established, these areas were among the better suited ones for crops.

Climate[8]

Mahaska County, located in southeast Iowa, is drained to the southeast by the Des Moines and Skunk Rivers. The topography is mostly hilly excepting flood plains. The Oskaloosa climatic record, summarized in table 7, is typical of the climate for the county.

About two-thirds of the annual precipitation and about 80 percent of heavy intensity showers fall from April through September. The average annual number of days with rainfalls equal to or exceeding 2 inches is 1, 1 inch or more is 6, ½ inch or more total 18, and ¼ inch or more is 36; this potentially can cause erosion during the season of soil tillage, particularly since most of Mahaska County is rolling terrain. The probability of heavier daily rainfalls are 5.5 inches once per 25 years, 6.0 inches once per 50 years, and 6.8 inches once

[8] By PAUL J. WAITE, climatologist for Iowa, National Weather Service, U.S. Department of Commerce.

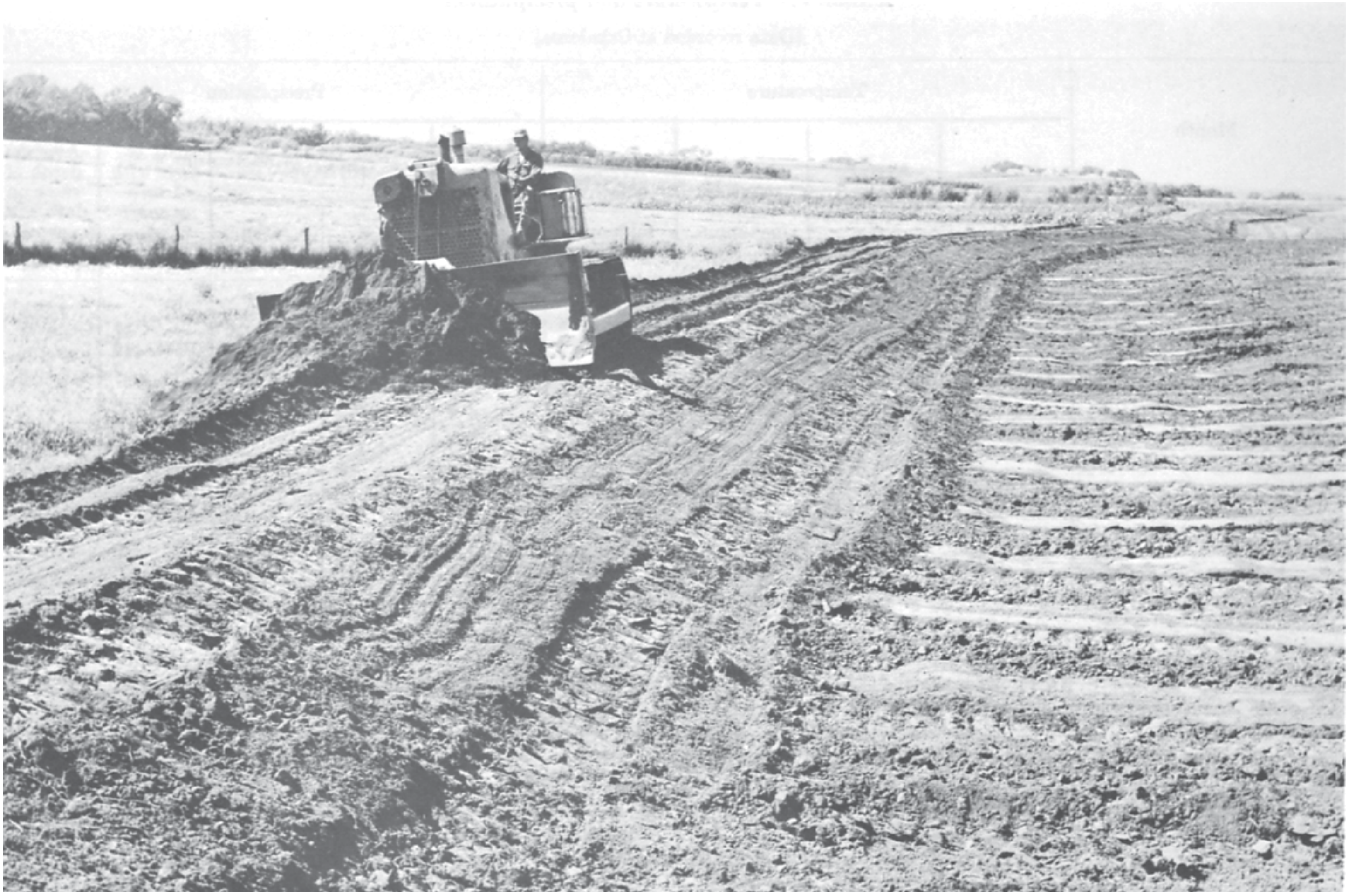

Figure 31.—**Construction of a diversion terrace on Radford silt loam to protect it from damage caused by runoff.**

per century. The annual number of days with measurable precipitation averages 104.

The average amount of snowfall received in the county is about 48 inches a year. The first inch of snowfall normally occurs around December 1. The greatest snow depth in recent years was 21 inches in March 1960. The only measurable October snowfall in recent years was a 2-inch snowfall on October 27, 1967, that melted rapidly.

Ideally, during the growing season subsoil moisture is moderate. Variations from the optimum are rather frequent, which on occasion reach extremes of flood to drought. Soil moisture reserves and rainfalls usually provide sufficient moisture for crops through May and June. If drought occurs, it is most likely in July or August. About 1 inch of available moisture per week is required for optimum corn growth. The probability of receiving an inch or more of rain each week in May and June is 30 to 40 percent except during the first 2 weeks of June when the chances increase to 50 and 45 percent, respectively; July probabilities are 25 to 30 percent, and August probabilities are 30 to 40 percent per week until the last week, in which the chances diminish to about 25 percent.

Maximum temperatures vary little over the county but nighttime minima may vary as much as 10° or 15° F on calm clear nights; the colder temperatures occur over the rural lowlands and in the valleys. The growing season of about 160 to 165 days extends from the last spring freeze around the end of April to about October 12.

Optimum corn growth is limited by hot weather, particularly when temperatures rise to 90° F or higher. Mahaska County normally reports about 33 days per year with temperatures 90° F or higher. In about half the years the Mahaska County temperature reaches to as high as 99° F. The highest temperature of record in Mahaska County is 112° F, and the coldest of record was −31°F.

Relief and Drainage

Mahaska County is part of an extensive glacial drift plain mantled with loess. It slopes gently toward the southeast and is cut by the Des Moines and Skunk Rivers, which also flow southeast. These valleys are generally 150 to 200 feet lower than the top of the divides between the rivers.

The relief ranges from nearly level to very steep. The least amount of relief is along the broadest and most stable parts of upland divides, and along the floor of the larger drainageways. The greatest amount of relief is along the edges of the valleys of the Des Moines and Skunk Rivers.

The lowest elevation in Mahaska County is less than 650 feet. It is near Eddyville in the valley of the Des Moines River at the southern border of the county. The highest

elevation is more than 920 feet. It is near Taintor on the divide between the North and South Skunk Rivers and is near the northern border of the county.

The landscape of Mahaska County is characteristic of that occurring in much of southern Iowa. The relief is related to the geologic deposits, especially those of Kansan and Wisconsin age.

The county is drained by the Des Moines, South Skunk, and North Skunk Rivers and their tributaries. Each of these drainage systems is oriented generally in a northwest to southeast direction, and drains approximately one-third of the county. The larger drainage systems are shown on the general soil map.

The Red Rock Dam on the Des Moines River is expected to reduce the flooding hazard and to stabilize the flow in the channel to some extent. Temporary flooding occurs along the Skunk River in some places almost every spring. Dikes from 2 to 8 feet in height have been built in some places to protect farmland from flooding.

Diversion terraces have been built in some places along the edge of valleys to protect alluvial soils from overflow by runoff water from the uplands (fig. 31).

Terraces in the uplands include the graded terrace with a surface outlet and the newer parallel terrace, which usually has a tile outlet and a grass backslope.

Subsurface tile drainage is used to improve the soil-moisture-plant relationship in poorly drained, and to some extent in somewhat poorly drained, soils. Open ditches are also used to a limited extent for this on bottom-land soils.

Water from tile lines, terraces, and diversions moves through tile lines, grassed waterways, or open ditches to ponds or streams.

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Glossary

Acidity. (See Reaction.)

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams. The term "local alluvium" used in this survey refers to alluvium that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bench. A long, narrow, relatively level or gently inclined strip or platform of soil or unconsolidated material bounded by steeper slopes above and below.

Bench terrace. A shelflike embankment of earth that has a level or nearly level top and a steep or nearly vertical downhill face, constructed along the contour of sloping land or across the slope to control runoff and erosion. The downhill face of the bench may be made of rocks or masonry, or it may be planted to vegetation.

Bottom, first. The normal flood plain of a stream; land along the stream subject to overflow.

Bottom land. The normal flood plain of a stream, part of which may be flooded infrequently.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Complex, soil. A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Contour tillage. Cultivating in rows at right angles to the natural direction of the slope or that are parallel to terrace grade.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate tetuxre.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial drift. Rock material transported by glacial ice and then deposited; includes the assorted and unassorted materials deposited by streams flowing from glaciers.

Glacial outwash. Crossbedded gravel, sand, and silt deposited by melt water as it flowed from glacial ice. Referred to in this survey as "outwash areas" or "outwashes."

Glacial till. Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Gumbotil. Grayish colored, strongly weathered layer at the top of Kansan or Nebraskan age glacial till.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Humus. The well-decomposed, more or less stable part of the organic matter in mineral soils.

Interfluve. The district between two adjacent streams flowing in the same direction.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Local alluvium. See Alluvium.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Loess-till contact line. The visible zone where loess immediately overlies glacial till.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many* size—*fine*, *medium*, and *coarse* and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Noncrossable gully. A gully that cannot reasonably be crossed by farm machinery.

Overwash material. Recent alluvial sediment that has accumulated on the surface of a soil.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Percolation. The downward movement of water through soil.

Pebble band. See Stone line.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Seepline. A zone where water accumulates in the soil material until the soil profile remains saturated.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Stone line. A concentration of coarse rock fragments in soils that generally represents an old weathering surface. In a cross section, the line may be one stone or more thick. The line generally overlies material that weathered in place, and it is ordinarily overlain by sediment of variable thickness.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of

unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Taxadjunct. Soils that are unclassified at the series level but allowed to go under the name of a defined series. They are so like the soils of the defined series in morphology, composition, and behavior that little or nothing is gained by adding a new series.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilty, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

Variant, soil. A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

Weathering. All physical and chemical changes produced in rocks at or near the earth's surface by atmospheric agents. These changes result in more or less complete disintegration and decomposition of the rock.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Well-graded soil. A soil or soil material consisting of particles that are well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the soil series to which the mapping unit belongs. In referring to a capability unit or a woodland suitability group, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

Acreage and extent, table 1, page 10.
Predicted yields, table 2, page 74.

Use of soils for engineering, tables 3, 4, and 5, pages 84 through 114.

Map symbol	Mapping unit	Page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
7	Wiota silt loam, 0 to 2 percent slopes	62	I-1	65	1o1	76
8B	Judson silty clay loam, 2 to 5 percent slopes	33	IIe-2	65	1o1	76
8C	Judson silty clay loam, 5 to 9 percent slopes	33	IIIe-1	68	1o1	76
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes	22	IIw-3	66	5w3	79
13B	Nodaway-Vesser silt loams, 2 to 5 percent slopes	46	IIw-3	66	5w2	79
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded	54	IVe-4	71	2o1	77
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded	54	IVe-4	71	2o1	77
41C	Sparta loamy fine sand, 4 to 9 percent slopes	55	IVs-1	72	4s1	78
43	Bremer silty clay loam, 0 to 2 percent slopes	14	IIw-2	66	5w3	79
51	Vesser silt loam, 0 to 2 percent slopes	60	IIw-2	66	5w3	79
51B	Vesser silt loam, 2 to 5 percent slopes	60	IIw-3	66	5w3	79
53	Riverwash	51	VIIs-3	73	---	--
54+	Zook silt loam, overwash, 0 to 2 percent slopes	63	IIIw-1	69	5w3	79
54	Zook silty clay loam, 0 to 2 percent slopes	63	IIIw-1	69	5w3	79
54B	Zook silty clay loam, 2 to 5 percent slopes	63	IIIw-1	69	5w3	79
63C	Chelsea loamy fine sand, 4 to 9 percent slopes	16	IVs-1	72	4s1	78
63D2	Chelsea loamy fine sand, 9 to 14 percent slopes, moderately eroded	16	VIs-1	72	4s1	78
63E2	Chelsea loamy fine sand, 14 to 18 percent slopes, moderately eroded	17	VIs-1	72	4s1	78
63F2	Chelsea loamy fine sand, 18 to 25 percent slopes, moderately eroded	17	VIIs-2	73	4s1	78
65D2	Lindley loam, 9 to 14 percent slopes, moderately eroded	39	IVe-3	71	2o1	77
65E2	Lindley loam, 14 to 18 percent slopes, moderately eroded	39	VIe-1	72	2o1	77
65F2	Lindley loam, 18 to 25 percent slopes, moderately eroded	39	VIIe-1	73	3r1	77
69C	Clearfield silty clay loam, 5 to 9 percent slopes	19	IIIw-3	70	5w3	79
69C2	Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded	19	IIIw-3	70	5w3	79
74	Rubio silt loam, 0 to 2 percent slopes	52	IIIw-2	70	5w3	79
75	Givin silt loam, 1 to 3 percent slopes	27	I-1	65	3w1	77
T75	Givin silt loam, benches, 1 to 3 percent slopes	27	I-1	65	3w1	77
76B	Ladoga silt loam, 2 to 5 percent slopes	35	IIe-1	65	1o1	76
76C	Ladoga silt loam, 5 to 9 percent slopes	35	IIIe-1	68	1o1	76
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	36	IIIe-1	68	1o1	76
76D	Ladoga silt loam, 9 to 14 percent slopes	36	IIIe-2	68	1o1	76
76D2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	36	IIIe-2	68	1o1	76
T76B	Ladoga silt loam, benches, 2 to 5 percent slopes	36	IIe-1	65	1o1	76
T76C2	Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded	36	IIIe-1	68	1o1	76
80B	Clinton silt loam, 2 to 5 percent slopes	20	IIe-1	65	1o1	76
80C	Clinton silt loam, 5 to 9 percent slopes	20	IIIe-1	68	1o1	76
80C2	Clinton silt loam, 5 to 9 percent slopes, moderately eroded	20	IIIe-1	68	1o1	76
80D2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded	20	IIIe-2	68	1o1	76
80D3	Clinton soils, 9 to 14 percent slopes, severely eroded	21	IVe-1	70	1o1	76
80E2	Clinton silt loam, 14 to 18 percent slopes, moderately eroded	21	IVe-1	70	1o1	76
88	Nevin silty clay loam, 0 to 2 percent slopes	43	I-1	65	3w1	77
98	Huntsville silt loam, 0 to 2 percent slopes	32	I-2	65	5w2	79
122	Sperry silt loam, 0 to 2 percent slopes	56	IIIw-2	70	5w3	79
131B	Pershing silt loam, 2 to 5 percent slopes	50	IIe-3	66	4w1	78
131C2	Pershing silt loam, 5 to 9 percent slopes, moderately eroded	50	IIIe-3	68	4w1	78

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Woodland suitability group Number	Woodland suitability group Page
132C2	Weller silt loam, 5 to 9 percent slopes, moderately eroded	62	IIIe-3	68	4w1	78
133+	Colo silt loam, overwash, 0 to 2 percent slopes	21	IIw-2	66	5w3	79
133	Colo silty clay loam, 0 to 2 percent slopes	22	IIw-2	66	5w3	79
133B	Colo silty clay loam, 2 to 5 percent slopes	22	IIw-3	66	5w3	79
T162B	Downs silt loam, benches, 2 to 5 percent slopes	23	IIe-1	65	1o1	76
163B	Fayette silt loam, 2 to 5 percent slopes	24	IIe-1	65	1o1	76
163C2	Fayette silt loam, 5 to 9 percent slopes, moderately eroded	24	IIIe-1	68	1o1	76
163D2	Fayette silt loam, 9 to 14 percent slopes, moderately eroded	24	IIIe-2	68	1o1	76
163E2	Fayette silt loam, 14 to 18 percent slopes, moderately eroded	24	IVe-1	70	1o1	76
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded	26	IVe-3	71	2o1	77
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded	26	VIe-1	72	2o1	77
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded	26	VIIe-1	73	3r1	77
208	Landes fine sandy loam, 0 to 2 percent slopes	38	IIw-4	67	5w2	79
210G	Boone fine sandy loam, 18 to 40 percent slopes	14	VIIs-1	73	5s1	78
212	Kennebec silt loam, 0 to 2 percent slopes	34	I-2	65	5w2	79
220	Nodaway silt loam, 0 to 2 percent slopes	45	IIw-5	67	5w2	79
C220	Nodaway silt loam, channeled, 0 to 2 percent slopes	45	Vw-1	72	5w2	79
222C	Clarinda silty clay loam, 5 to 9 percent slopes	18	IIIe-4	69	5w1	79
222C2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	18	IIIe-4	69	5w1	79
222D2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	18	IVe-2	70	5w1	79
248	Zook silty clay loam, depressional, 0 to 1 percent slopes	63	IIIw-1	69	5w3	79
269	Humeston silt loam, 0 to 2 percent slopes	32	IIIw-2	70	5w3	79
270	Spillville loam, sandy substratum, 0 to 2 percent slopes	57	IIw-5	67	5w2	79
273B	Olmitz loam, 2 to 5 percent slopes	47	IIe-2	65	2o1	77
273C	Olmitz loam, 5 to 9 percent slopes	47	IIIe-1	68	2o1	77
279	Taintor silty clay loam, 0 to 2 percent slopes	58	IIw-1	66	5w3	79
T279	Taintor silty clay loam, benches, 0 to 2 percent slopes	58	IIw-1	66	5w3	79
280	Mahaska silty clay loam, 0 to 2 percent slopes	41	I-1	65	3w1	77
280B	Mahaska silty clay loam, 2 to 5 percent slopes	41	IIe-1	65	3w1	77
T280	Mahaska silty clay loam, benches, 1 to 3 percent slopes	41	I-1	65	3w1	77
281B	Otley silty clay loam, 2 to 5 percent slopes	48	IIe-1	65	1o1	76
281C	Otley silty clay loam, 5 to 9 percent slopes	48	IIIe-1	68	1o1	76
281C2	Otley silty clay loam, 5 to 9 percent slopes, moderately eroded	48	IIIe-1	68	1o1	76
281D	Otley silty clay loam, 9 to 14 percent slopes	49	IIIe-2	68	1o1	76
281D2	Otley silty clay loam, 9 to 14 percent slopes, moderately eroded	49	IIIe-2	68	1o1	76
T281B	Otley silty clay loam, benches, 2 to 5 percent slopes	49	IIe-1	65	1o1	76
T281C2	Otley silty clay loam, benches, 5 to 9 percent slopes, moderately eroded	49	IIIe-1	68	1o1	76
284	Flagler fine sandy loam, 0 to 2 percent slopes	25	IIIs-1	70	4s1	78
293C2	Chelsea-Clinton complex, 5 to 9 percent slopes, moderately eroded	17	IVs-1	72	4s1	78
293D2	Chelsea-Clinton complex, 9 to 14 percent slopes, moderately eroded	17	IVe-5	71	4s1	78
293E2	Chelsea-Clinton complex, 14 to 18 percent slopes, moderately eroded	17	VIs-1	72	4s1	78
313D	Gosport silt loam, 9 to 14 percent slopes	28	VIIe-2	73	5w1	79
313E	Gosport silt loam, 14 to 18 percent slopes	28	VIIe-2	73	5w1	79
313F	Gosport silt loam, 18 to 25 percent slopes	28	VIIe-2	73	5w1	79
315	Nodaway-Alluvial land complex, 0 to 2 percent slopes	46	Vw-1	72	5w2	79
354	Marsh	41	VIIw-1	73	---	--
362	Haig silt loam, 0 to 2 percent slopes	30	IIw-1	66	5w3	79
364B	Grundy silty clay loam, 2 to 5 percent slopes	29	IIe-3	66	4w1	78
364C2	Grundy silty clay loam, 5 to 9 percent slopes, moderately eroded	29	IIIe-3	68	4w1	78
412G	Sogn silt loam, 18 to 40 percent slopes	54	VIIs-1	73	5s1	78
422	Amana silty clay loam, 0 to 2 percent slopes	12	I-2	65	5w2	79
C422	Amana complex, channeled, 0 to 2 percent slopes	12	Vw-1	72	5w2	79
424D2	Lindley-Keswick complex, 9 to 14 percent slopes, moderately eroded	40	IVe-3	71	2o1	77
424E2	Lindley-Keswick complex, 14 to 18 percent slopes, moderately eroded	40	VIe-1	72	2o1	77
428B	Ely silty clay loam, 2 to 5 percent slopes	23	IIe-2	65	3w1	77
442C2	Sparta-Otley complex, 5 to 9 percent slopes, moderately eroded	55	IVs-1	72	4s1	78
442D2	Sparta-Otley complex, 9 to 14 percent slopes, moderately eroded	56	IVe-5	71	4s1	78
451D2	Caleb loam, 9 to 14 percent slopes, moderately eroded	15	IVe-3	71	2o1	77

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Woodland suitability group Number	Woodland suitability group Page
451E2	Caleb loam, 14 to 18 percent slopes, moderately eroded	16	VIe-1	72	2o1	77
451F2	Caleb loam, 18 to 25 percent slopes, moderately eroded	16	VIIe-1	73	3r1	77
453	Tuskeego silt loam, 0 to 2 percent slopes	59	IIIw-2	70	5w3	79
467	Radford silt loam, 0 to 2 percent slopes	50	IIw-5	67	5w2	79
485	Spillville loam, 0 to 2 percent slopes	57	IIw-5	67	5w2	79
489	Ossian silt loam, 0 to 2 percent slopes	47	IIw-2	66	5w3	79
502	Mine pits and dumps	42	-----	--	---	--
570B	Nira silty clay loam, 2 to 5 percent slopes	44	IIe-1	65	1o1	76
570C	Nira silty clay loam, 5 to 9 percent slopes	44	IIIe-1	68	1o1	76
570C2	Nira silty clay loam, 5 to 9 percent slopes, moderately eroded	45	IIIe-1	68	1o1	76
571B	Hedrick silt loam, 2 to 5 percent slopes	31	IIe-1	65	1o1	76
571C	Hedrick silt loam, 5 to 9 percent slopes	31	IIIe-1	68	1o1	76
571C2	Hedrick silt loam, 5 to 9 percent slopes, moderately eroded	31	IIIe-1	68	1o1	76
571D2	Hedrick silt loam, 9 to 14 percent slopes, moderately eroded	31	IIIe-2	68	1o1	76
571E2	Hedrick silt loam, 14 to 18 percent slopes, moderately eroded	31	IVe-1	70	1o1	76
663D2	Seaton silt loam, 9 to 14 percent slopes, moderately eroded	53	IIIe-2	68	1o1	76
663E2	Seaton silt loam, 14 to 18 percent slopes, moderately eroded	53	IVe-1	70	1o1	76
663F2	Seaton silt loam, 18 to 25 percent slopes, moderately eroded	53	VIe-2	72	2r1	77
687	Watkins silt loam, 0 to 2 percent slopes	61	I-1	65	1o1	76
687B	Watkins silt loam, 2 to 5 percent slopes	61	IIe-1	65	1o1	76
792D2	Armstrong loam, 9 to 14 percent slopes, moderately eroded	13	IVe-2	70	5c1	78
822C2	Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	37	IIIe-4	69	5w1	79
822D2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	37	IVe-2	70	5w1	79
993D2	Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded	26	IVe-4	71	2o1	77
993E2	Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	26	VIe-1	72	2o1	77

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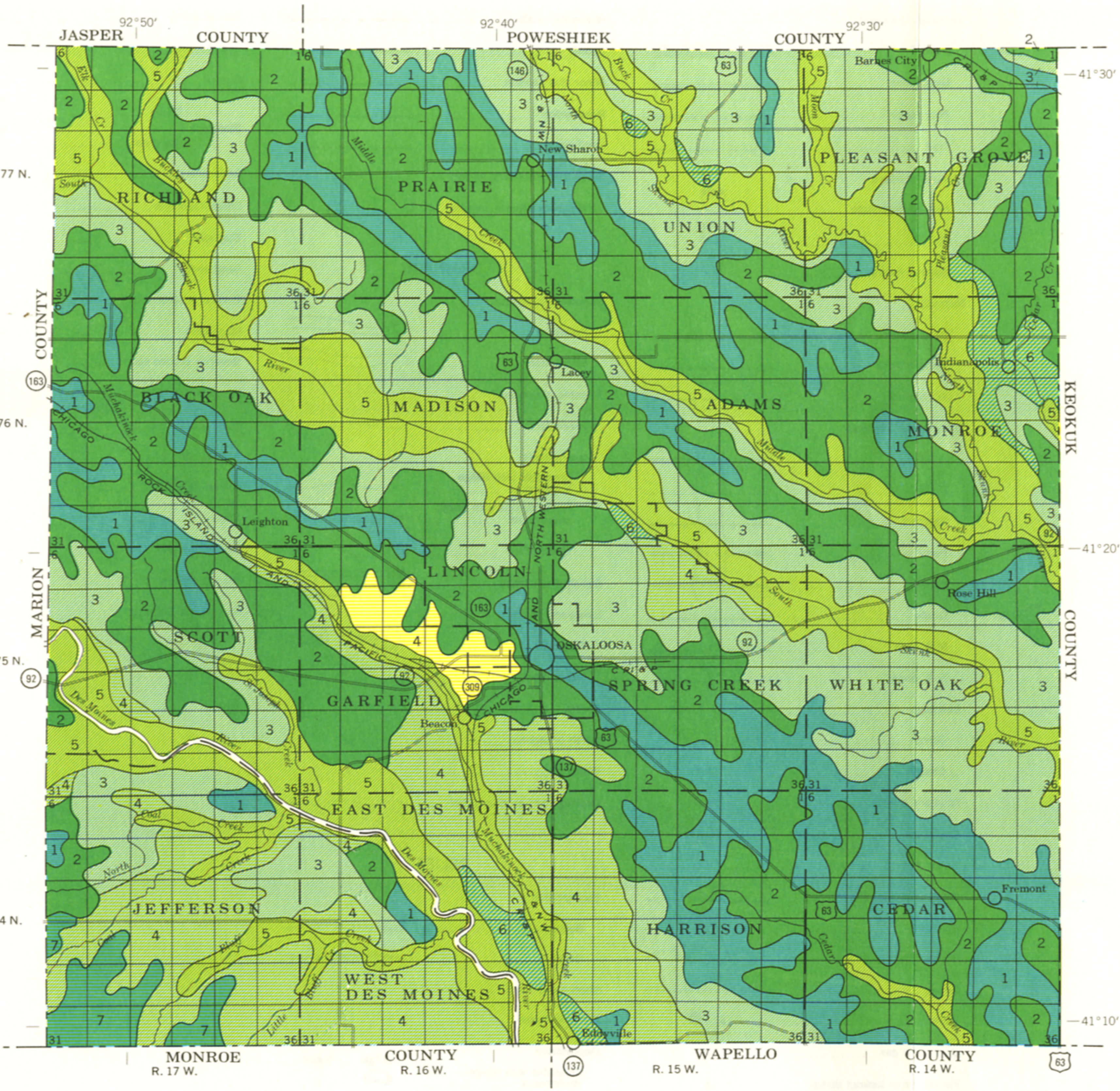
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY
DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

GENERAL SOIL MAP

MAHASKA COUNTY, IOWA

Scale 1:190,080

1 0 1 2 3 4 Miles



SOIL ASSOCIATIONS

1 — Mahaska-Taintor association: Nearly level and gently sloping, somewhat poorly drained and poorly drained soils that have a subsoil of silty clay loam or silty clay; on uplands

2 — Otley-Ladoga-Nira association: Gently sloping to strongly sloping, moderately well drained soils that have a subsoil of silty clay loam; on uplands

3 — Clinton-Lindley-Gara association: Gently sloping to steep, well drained and moderately well drained soils that have a subsoil of silty clay loam or clay loam; on uplands

4 — Ladoga-Clinton-Gosport association: Gently sloping to steep, moderately well drained soils that have a subsoil of silty clay loam or silty clay; on uplands

5 — Colo-Nodaway-Zook association: Nearly level and gently sloping, poorly drained to moderately well drained soils that are dominantly silty clay loam and silt loam throughout or that have a subsoil of silty clay loam or silty clay; on bottom lands

6 — Clinton-Chelsea association: Moderately sloping to steep, moderately well drained and excessively drained soils that have a subsoil of silty clay loam or that are loamy fine sand and fine sand throughout; on uplands

7 — Pershing-Grundy-Haig association: Moderately sloping to nearly level, moderately well drained to poorly drained soils that have a subsoil of silty clay and silty clay loam; on uplands

Compiled 1975

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

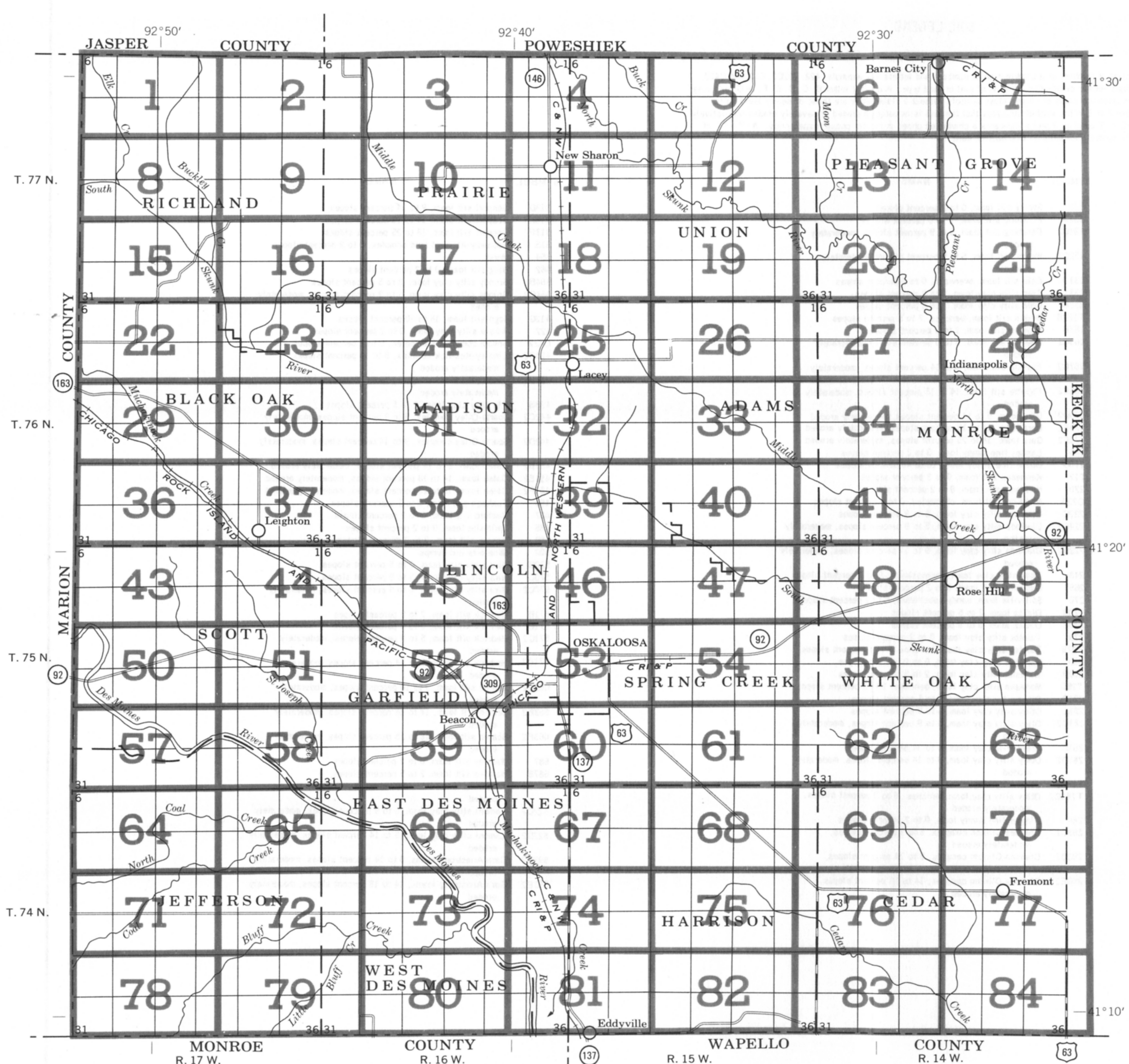
INDEX TO MAP SHEETS

MAHASKA COUNTY, IOWA

Scale 1:190,080

1 0 1 2 3 4 Miles

N



SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

MAHASKA COUNTY, IOWA

IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY
DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

SOIL LEGEND

Symbols consist of numbers or a combination of numbers and letters--for example, 422, 792D2, 63C and C422. The 2 or 3 digit number designates the kind of soil or land type. A capital letter B, C, D, E, F, or G following a number indicates the class of slope. Most symbols without a slope letter are those of nearly level soils. A final number 2 or 3 in the symbol indicates that the soil is moderately eroded or severely eroded respectively. The capital C or T used as a prefix indicates a channeled phase or bench phase respectively. A "+" at the end of the symbol indicates an overwashed soil.

SYMBOL	NAME
7	Wiota silt loam, 0 to 2 percent slopes
8B	Judson silty clay loam, 2 to 5 percent slopes
8C	Judson silty clay loam, 5 to 9 percent slopes
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes
13B	Nodaway-Vesser silt loams, 2 to 5 percent slopes
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded
41C	Sparta loamy fine sand, 4 to 9 percent slopes
43	Bremer silty clay loam, 0 to 2 percent slopes
51	Vesser silt loam, 0 to 2 percent slopes
51B	Vesser silt loam, 2 to 5 percent slopes
53	Riverwash
54 +	Zook silt loam, overwash, 0 to 2 percent slopes
54	Zook silty clay loam, 0 to 2 percent slopes
54B	Zook silty clay loam, 2 to 5 percent slopes
63C	Chelsea loamy fine sand, 4 to 9 percent slopes
63D2	Chelsea loamy fine sand, 9 to 14 percent slopes, moderately eroded
63E2	Chelsea loamy fine sand, 14 to 18 percent slopes, moderately eroded
63F2	Chelsea loamy fine sand, 18 to 25 percent slopes, moderately eroded
65D2	Lindley loam, 9 to 14 percent slopes, moderately eroded
65E2	Lindley loam, 14 to 18 percent slopes, moderately eroded
65F2	Lindley loam, 18 to 25 percent slopes, moderately eroded
69C	Clearfield silty clay loam, 5 to 9 percent slopes
69C2	Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded
74	Rubio silt loam, 0 to 2 percent slopes
75	Givin silt loam, 1 to 3 percent slopes
T75	Givin silt loam, benches, 1 to 3 percent slopes
76B	Ladoga silt loam, 2 to 5 percent slopes
76C	Ladoga silt loam, 5 to 9 percent slopes
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded
76D	Ladoga silt loam, 9 to 14 percent slopes
76D2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded
T76B	Ladoga silt loam, benches, 2 to 5 percent slopes
T76C2	Ladoga silt loam, benches, 5 to 9 percent slopes, moderately eroded
80B	Clinton silt loam, 2 to 5 percent slopes
80C	Clinton silt loam, 5 to 9 percent slopes
80C2	Clinton silt loam, 5 to 9 percent slopes, moderately eroded
80D2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded
80D3	Clinton soils, 9 to 14 percent slopes, severely eroded
80E2	Clinton silt loam, 14 to 18 percent slopes, moderately eroded
88	Nevin silty clay loam, 0 to 2 percent slopes
98	Huntsville silt loam, 0 to 2 percent slopes

SYMBOL	NAME
122	Sperry silt loam, 0 to 2 percent slopes
131B	Pershing silt loam, 2 to 5 percent slopes
131C2	Pershing silt loam, 5 to 9 percent slopes, moderately eroded
132C2	Weller silt loam, 5 to 9 percent slopes, moderately eroded
133 +	Colo silt loam, overwash, 0 to 2 percent slopes
133	Colo silty clay loam, 0 to 2 percent slopes
133B	Colo silty clay loam, 2 to 5 percent slopes
T162B	Downs silt loam, benches, 2 to 5 percent slopes
163B	Fayette silt loam, 2 to 5 percent slopes
163C2	Fayette silt loam, 5 to 9 percent slopes, moderately eroded
163D2	Fayette silt loam, 9 to 14 percent slopes, moderately eroded
163E2	Fayette silt loam, 14 to 18 percent slopes, moderately eroded
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded
208	Landes fine sandy loam, 0 to 2 percent slopes
210G	Boone fine sandy loam, 18 to 40 percent slopes
212	Kennebec silt loam, 0 to 2 percent slopes
220	Nodaway silt loam, 0 to 2 percent slopes
C220	Nodaway silt loam, channeled, 0 to 2 percent slopes
222C	Clarinda silty clay loam, 5 to 9 percent slopes
222C2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded
222D2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded
248	Zook silty clay loam, depressional, 0 to 1 percent slopes
269	Humeston silt loam, 0 to 2 percent slopes
270	Spillville loam, sandy substratum, 0 to 2 percent slopes
273B	Olmitz loam, 2 to 5 percent slopes
273C	Olmitz loam, 5 to 9 percent slopes
279	Taintor silty clay loam, 0 to 2 percent slopes
T279	Taintor silty clay loam, benches, 0 to 2 percent slopes
280	Mahaska silty clay loam, 0 to 2 percent slopes
280B	Mahaska silty clay loam, 2 to 5 percent slopes
T280	Mahaska silty clay loam, benches, 1 to 3 percent slopes
281B	Otley silty clay loam, 2 to 5 percent slopes
281C	Otley silty clay loam, 5 to 9 percent slopes
281C2	Otley silty clay loam, 5 to 9 percent slopes, moderately eroded
281D	Otley silty clay loam, 9 to 14 percent slopes
281D2	Otley silty clay loam, 9 to 14 percent slopes, moderately eroded
T281B	Otley silty clay loam, benches, 2 to 5 percent slopes
T281C2	Otley silty clay loam, benches, 5 to 9 percent slopes, moderately eroded
284	Flagler fine sandy loam, 0 to 2 percent slopes
293C2	Chelsea-Clinton complex, 5 to 9 percent slopes, moderately eroded
293D2	Chelsea-Clinton complex, 9 to 14 percent slopes, moderately eroded
293E2	Chelsea-Clinton complex, 14 to 18 percent slopes, moderately eroded

SYMBOL	NAME
313D	Gosport silt loam, 9 to 14 percent slopes
313E	Gosport silt loam, 14 to 18 percent slopes
313F	Gosport silt loam, 18 to 25 percent slopes
315	Nodaway-Alluvial land complex, 0 to 2 percent slopes
354	Marsh
362	Haig silt loam, 0 to 2 percent slopes
364B	Grundy silty clay loam, 2 to 5 percent slopes
364C2	Grundy silty clay loam, 5 to 9 percent slopes, moderately eroded
412G	Sogn silt loam, 18 to 40 percent slopes
422	Amana silty clay loam, 0 to 2 percent slopes
C422	Amana complex, channeled, 0 to 2 percent slopes
424D2	Lindley-Keswick complex, 9 to 14 percent slopes, moderately eroded
424E2	Lindley-Keswick complex, 14 to 18 percent slopes, moderately eroded
428B	Ely silty clay loam, 2 to 5 percent slopes
442C2	Sparta-Otley complex, 5 to 9 percent slopes, moderately eroded
442D2	Sparta-Otley complex, 9 to 14 percent slopes, moderately eroded
451D2	Caleb loam, 9 to 14 percent slopes, moderately eroded
451E2	Caleb loam, 14 to 18 percent slopes, moderately eroded
451F2	Caleb loam, 18 to 25 percent slopes, moderately eroded
453	Tuskego silt loam, 0 to 2 percent slopes
467	Radford silt loam, 0 to 2 percent slopes
485	Spillville loam, 0 to 2 percent slopes
489	Ossian silt loam, 0 to 2 percent slopes
502	Mine pits and dumps
570B	Nira silty clay loam, 2 to 5 percent slopes
570C	Nira silty clay loam, 5 to 9 percent slopes
570C2	Nira silty clay loam, 5 to 9 percent slopes, moderately eroded
571B	Hedrick silt loam, 2 to 5 percent slopes
571C	Hedrick silt loam, 5 to 9 percent slopes
571C2	Hedrick silt loam, 5 to 9 percent slopes, moderately eroded
571D2	Hedrick silt loam, 9 to 14 percent slopes, moderately eroded
663D2	Seaton silt loam, 9 to 14 percent slopes, moderately eroded
663E2	Seaton silt loam, 14 to 18 percent slopes, moderately eroded
663F2	Seaton silt loam, 18 to 25 percent slopes, moderately eroded
687	Watkins silt loam, 0 to 2 percent slopes
687B	Watkins silt loam, 2 to 5 percent slopes
792D2	Armstrong loam, 9 to 14 percent slopes, moderately eroded
822C2	Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded
822D2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded
993D2	Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded
993E2	Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded

MAHASKA COUNTY, IOWA

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads

- Divided
- Good motor
- Poor motor
- Trail

Highway markers

- National Interstate
- U. S.
- State or county

Railroads

- Single track
- Multiple track
- Abandoned

Bridges and crossings

- Road
- Trail
- Railroad
- Ferry — FY
- Ford — FORD
- Grade
- R. R. over
- R. R. under

Buildings

- School
- Church

Mine and quarry — QU

Gravel pit — G.P.

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

Located object

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line

- Perennial
- Intermittent

Streams, single-line

- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
  - Unclassified

Canals and ditches

Lakes and ponds

- Perennial — water — w
- Intermittent — int

Spring

Marsh or swamp

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments

- Bedrock
- Other

Short steep slope

Prominent peak

Depressions — Large — Small

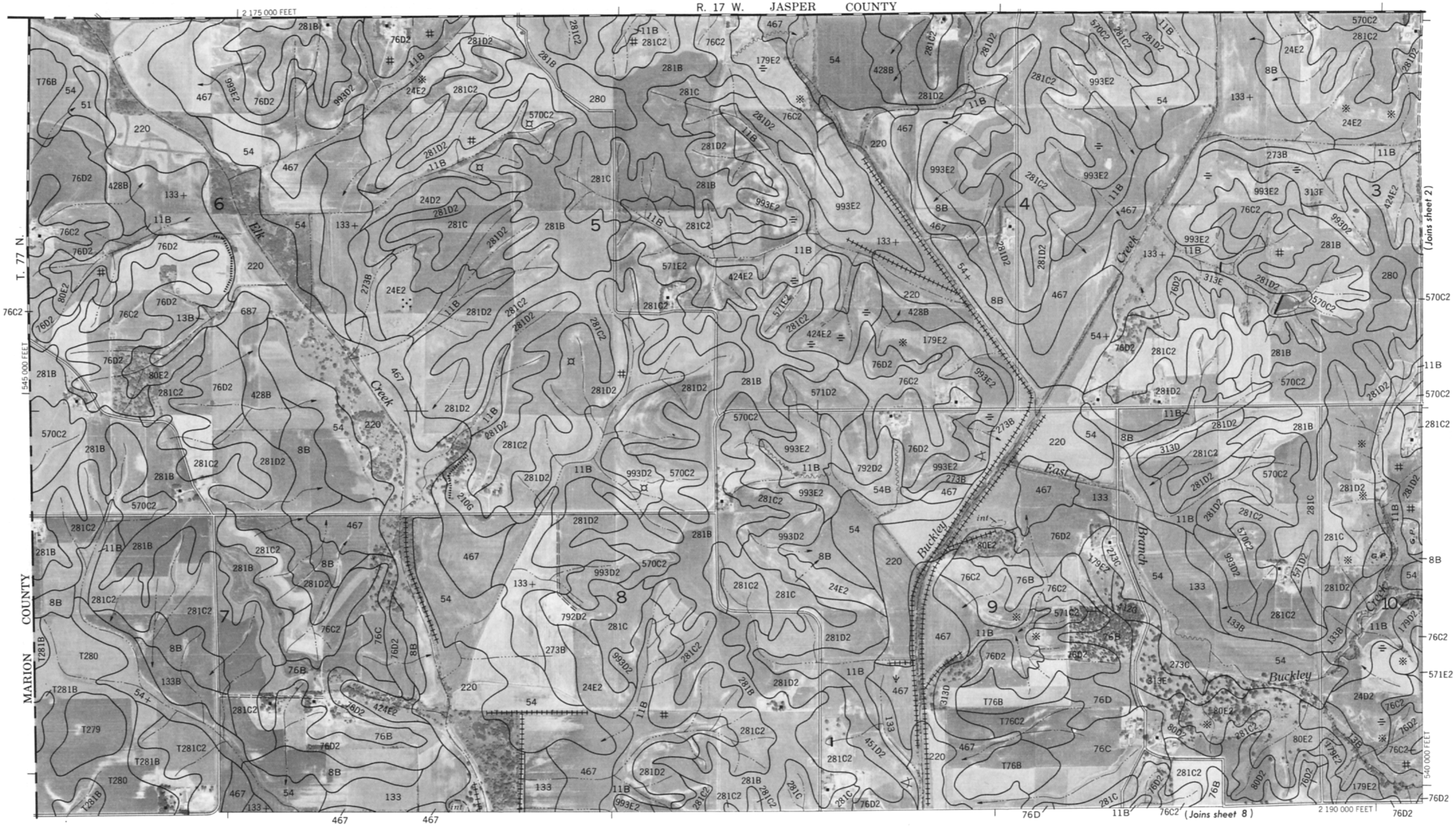
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

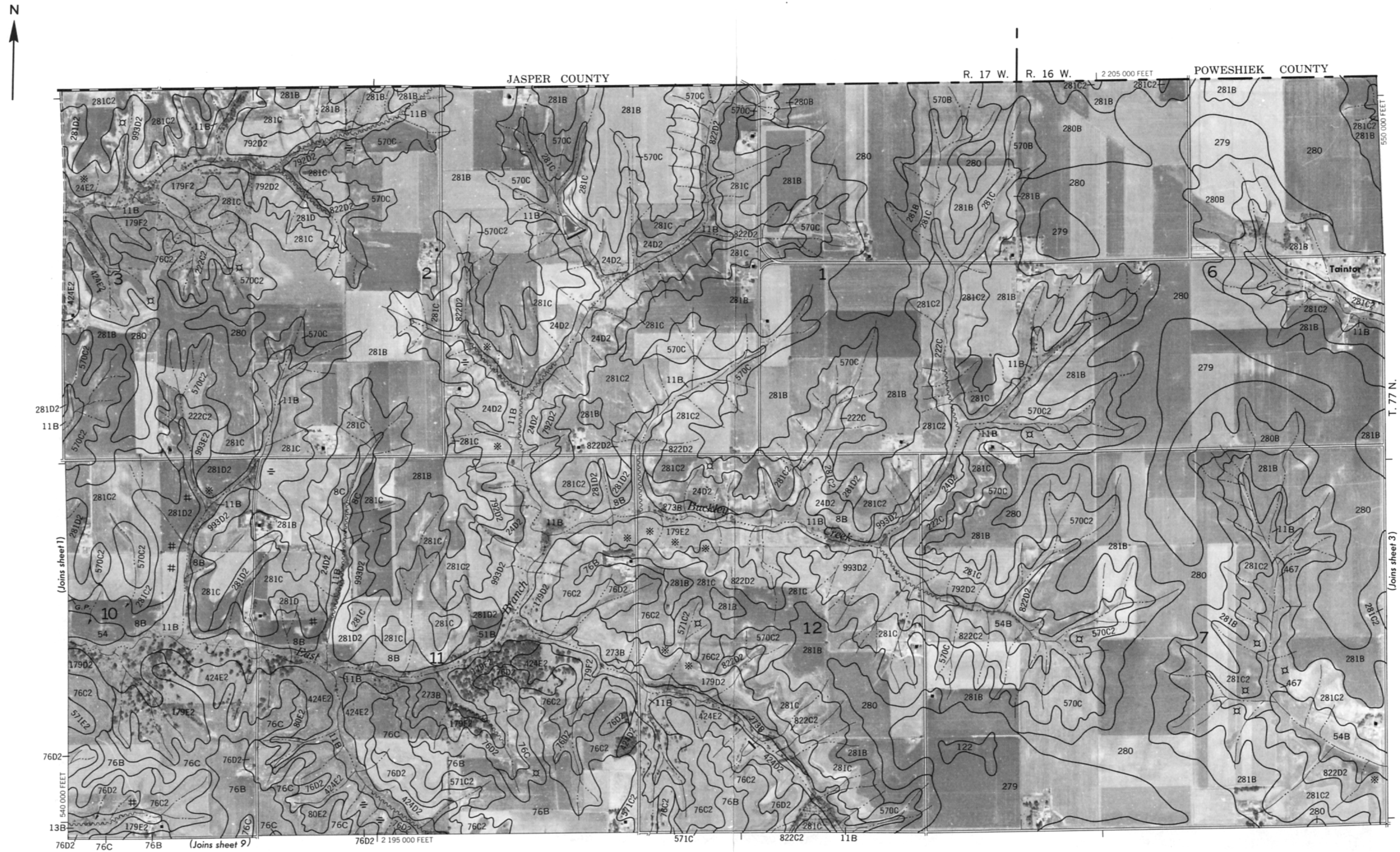
SOIL SURVEY DATA

- Soil boundary and symbol — Dx
- Gravel
- Stoniness
  - Stony
  - Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land — M.L.
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Borrow pit — B.P.
- Glacial till
- Shale
- Calcareous spot
- Sewage lagoon — S.L.
- Spot of gray Paleosol 0 to 40 inches

1

N

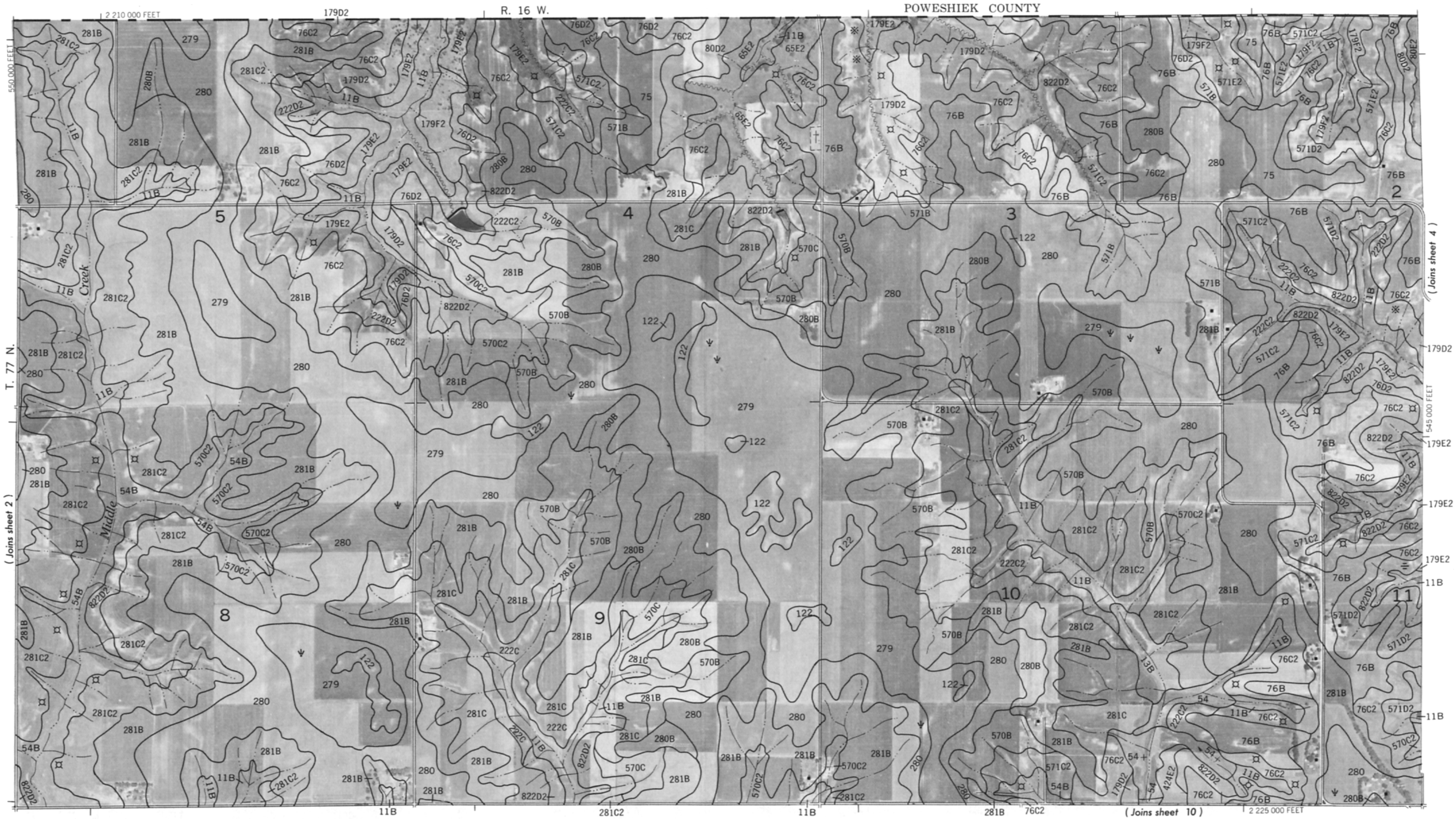

R. 17 W.
JASPER COUNTY
2 175 000 FEET
T. 77 N.
545 000 FEET
MARION COUNTY
(Joins sheet 2)
(Joins sheet 8)
2 190 000 FEET
540 000 FEET
Elk Creek
East Buckley Branch
Buckley Creek
Creek
1
2
3
4
5
6
7
8
9
10


2
N
JASPER COUNTY
POWESHIEK COUNTY
R. 17 W.
R. 16 W.
T. 77 N.
2 205 000 FEET
550 000 FEET
540 000 FEET
2 195 000 FEET
Taintor
Buckley
Creek
East
Branch
(Joins sheet 1)
(Joins sheet 3)
(Joins sheet 9)

MAHASKA COUNTY, IOWA — SHEET NUMBER 3

3

N



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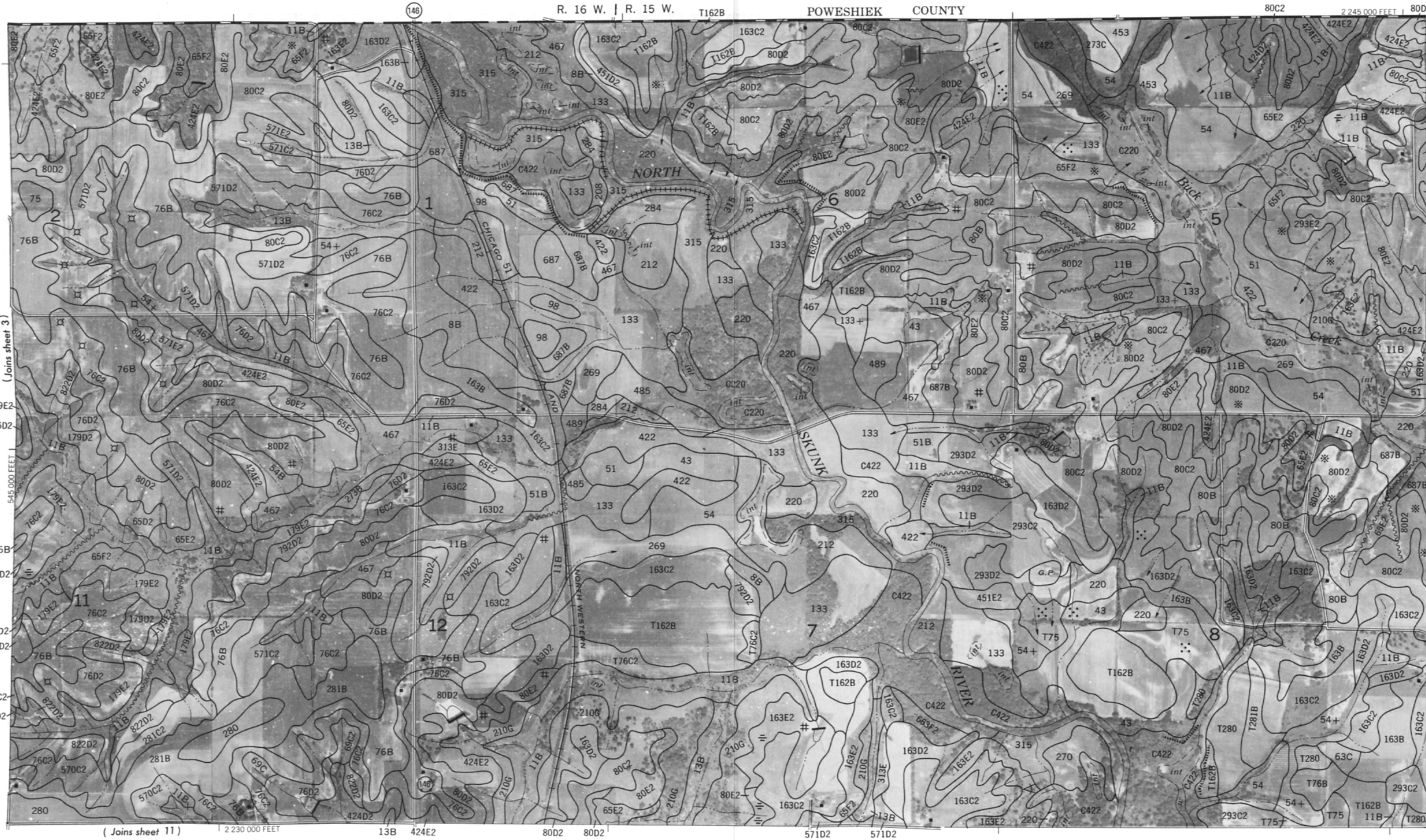
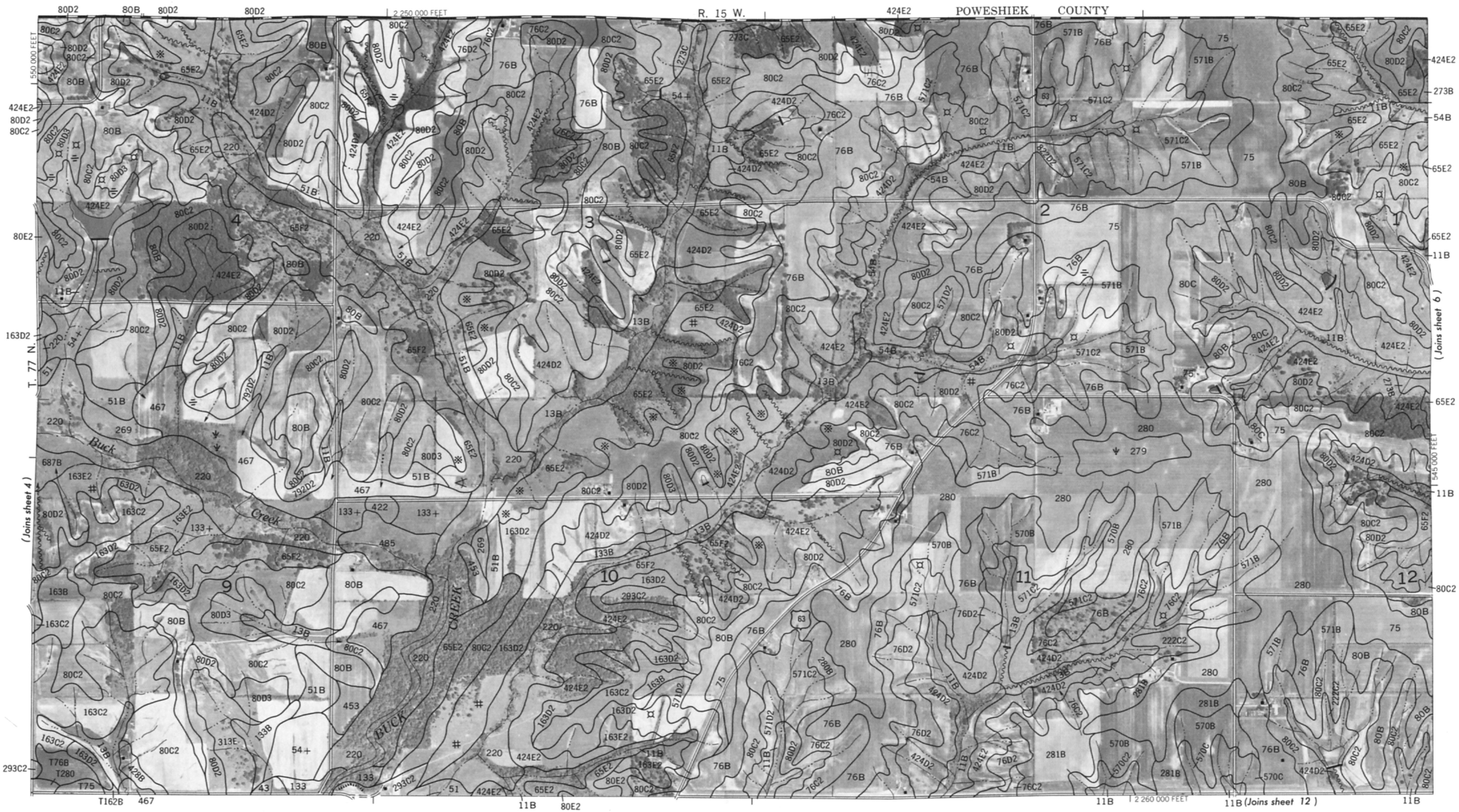
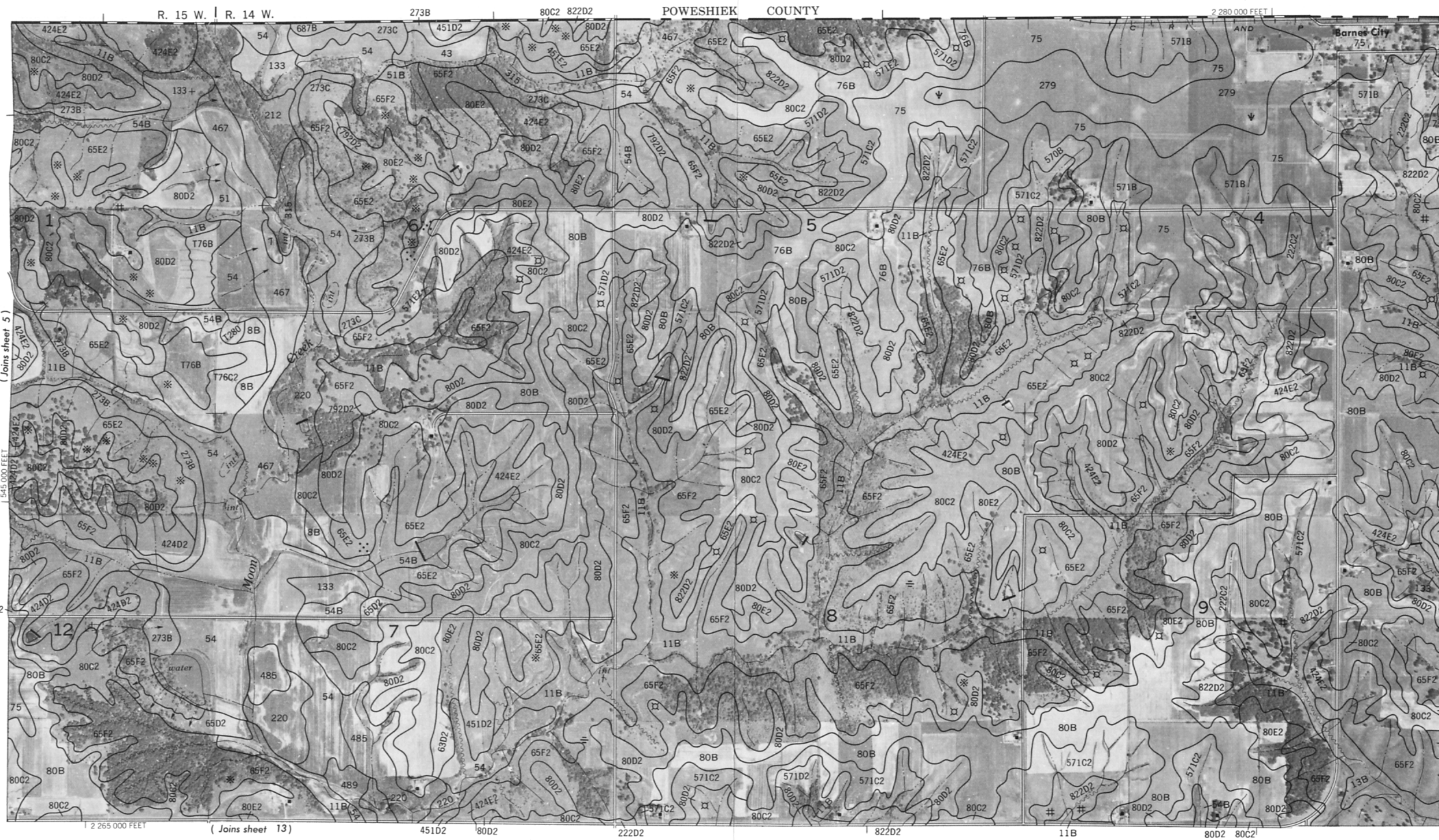
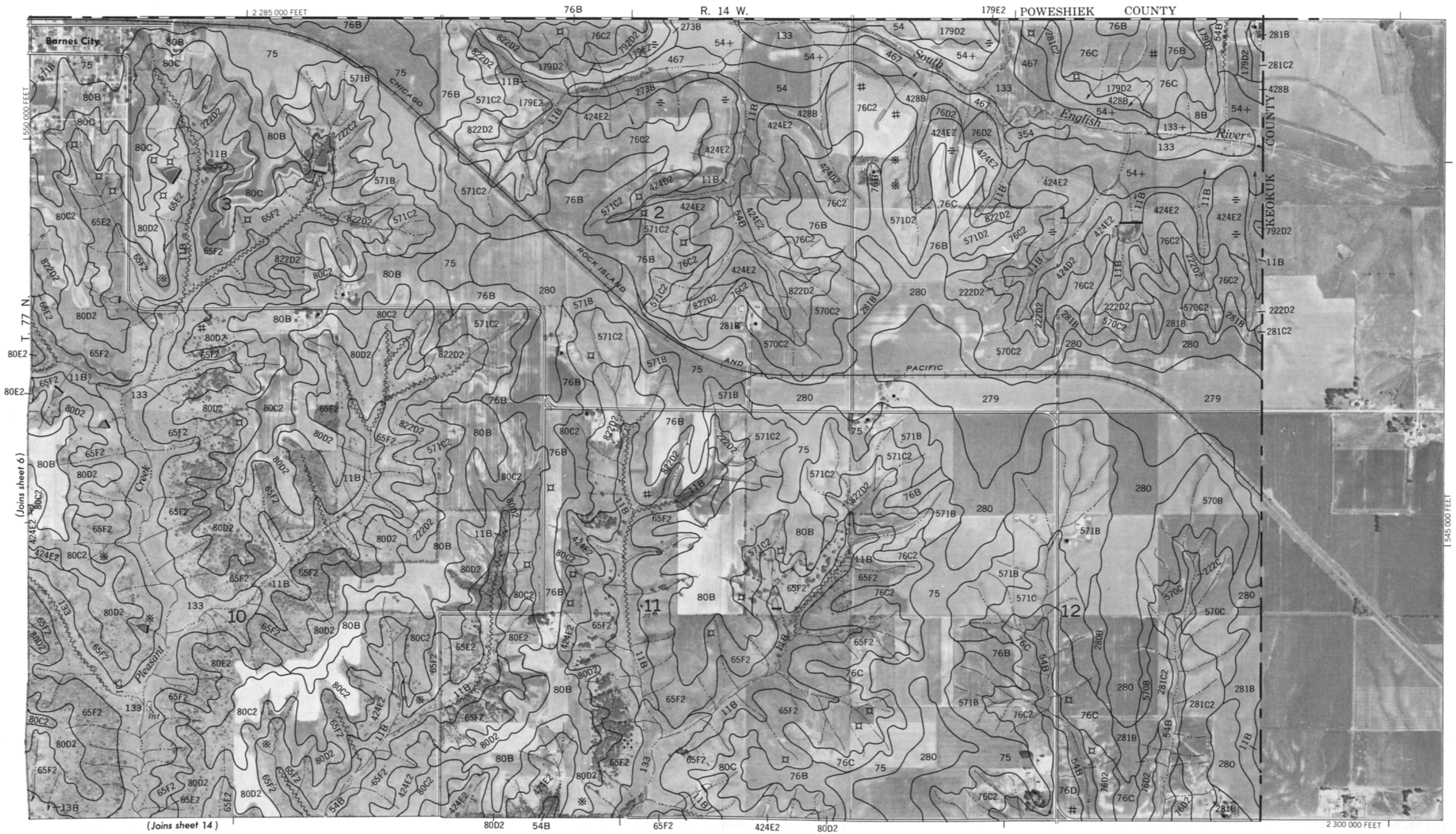

R. 16 W.
R. 15 W.
POWESHIEK COUNTY
2 245 000 FEET
550 000 FEET
545 000 FEET
2 230 000 FEET
T. 77 N.
NORTH SKUNK RIVER
Buck Creek
CHICAGO AND NORTH WESTERN
(Joins sheet 3)
(Joins sheet 5)
(Joins sheet 11)
146
G.P.

N


POWESHIEK COUNTY
R. 15 W.
T. 77 N.
2 250 000 FEET
2 260 000 FEET
550 000 FEET
545 000 FEET
(Joins sheet 4)
(Joins sheet 6)
(Joins sheet 12)
Buck Creek
BUCK CREEK
BUCK

N


POWESHIEK COUNTY
R. 15 W.
R. 14 W.
T. 77 N.
2 280 000 FEET
550 000 FEET
545 000 FEET
2 265 000 FEET
Barnes City
Moon Creek
water
(Joins sheet 5)
(Joins sheet 7)
(Joins sheet 13)

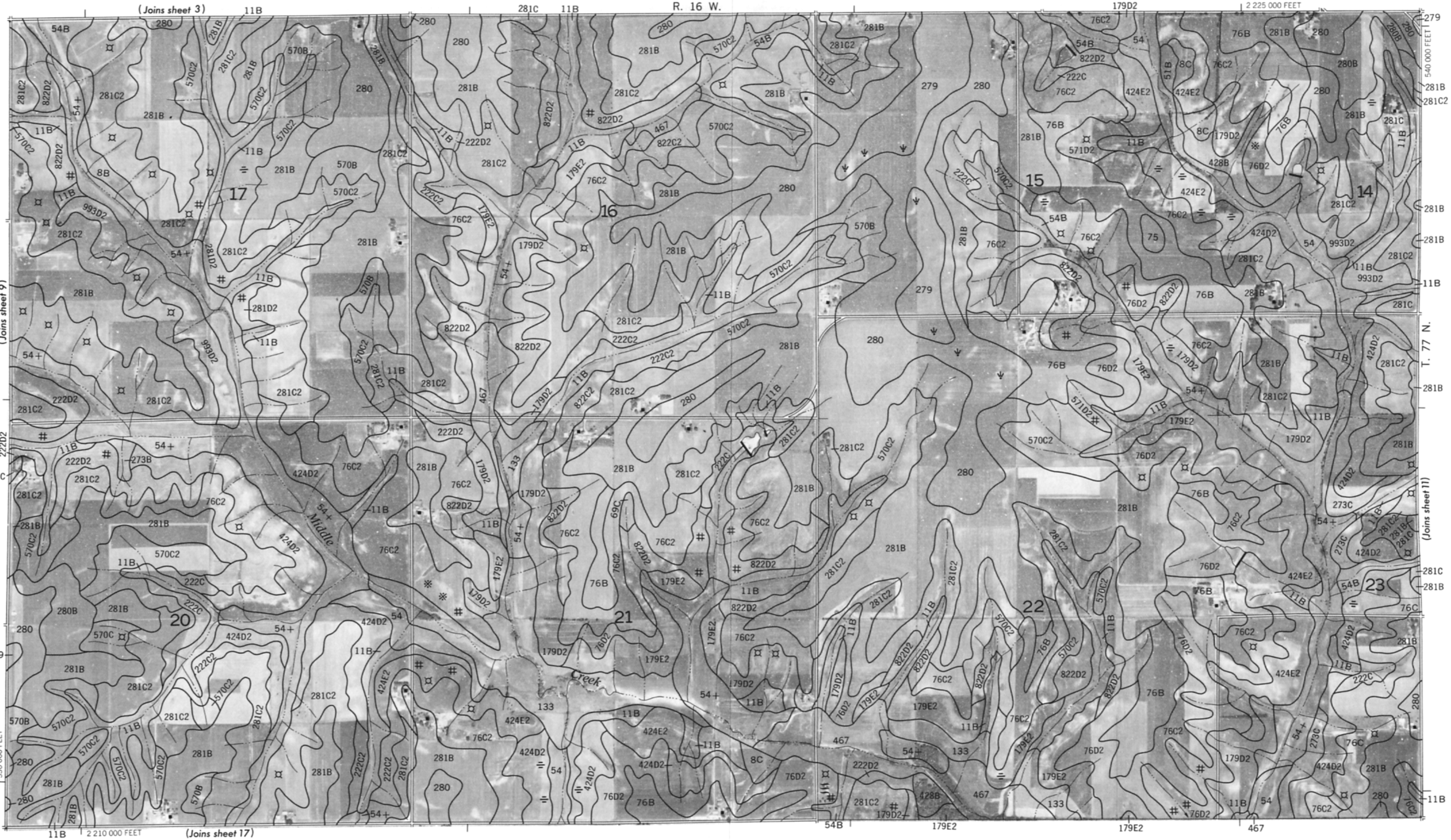

N
2 285 000 FEET
R. 14 W.
POWESHIEK COUNTY
KEOKUK COUNTY
T. 77 N.
550 000 FEET
545 000 FEET
2 300 000 FEET
Barnes City
South English River
CHICAGO ROCK ISLAND AND PACIFIC
Pleasant Creek
(Joins sheet 6)
(Joins sheet 14)
1
2
3
10
11
12

N


(Joins sheet 1)
R. 17 W.
2 190 000 FEET
T. 77 N.
535 000 FEET
(Joins sheet 9)
MARION COUNTY
530 000 FEET
2 175 000 FEET
(Joins sheet 15)
SOUTH SKUNK RIVER
Elk Creek
Buckley Creek
18
17
16
15
19
20
21
22

(10)

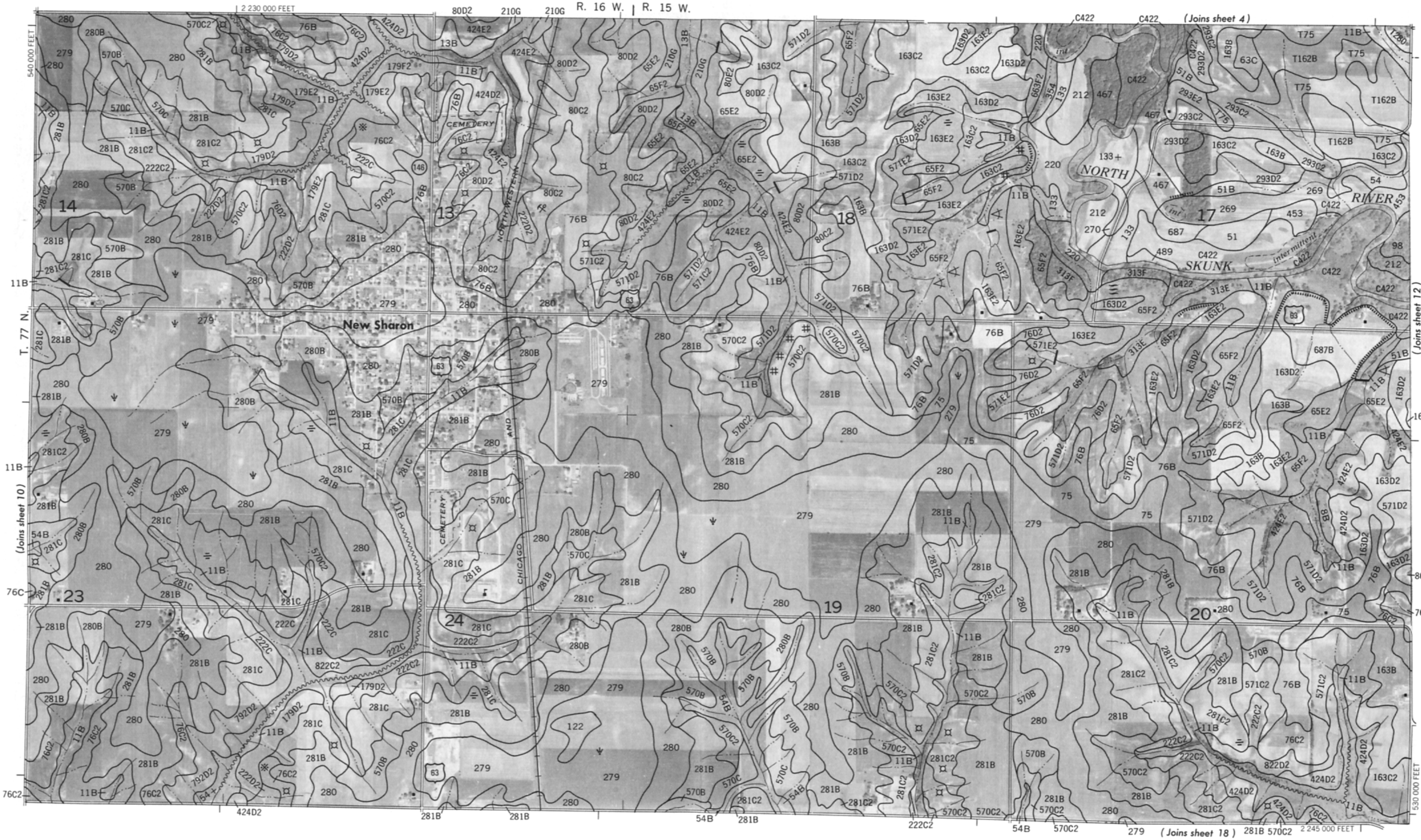
N


(Joins sheet 3)
R. 16 W.
2 225 000 FEET
540 000 FEET
T. 77 N.
(Joins sheet 11)
(Joins sheet 9)
(Joins sheet 17)
2 210 000 FEET
530 000 FEET
Middle
Creek
14
15
16
17
20
21
22
23

MAHASKA COUNTY, IOWA — SHEET NUMBER 11

11

N



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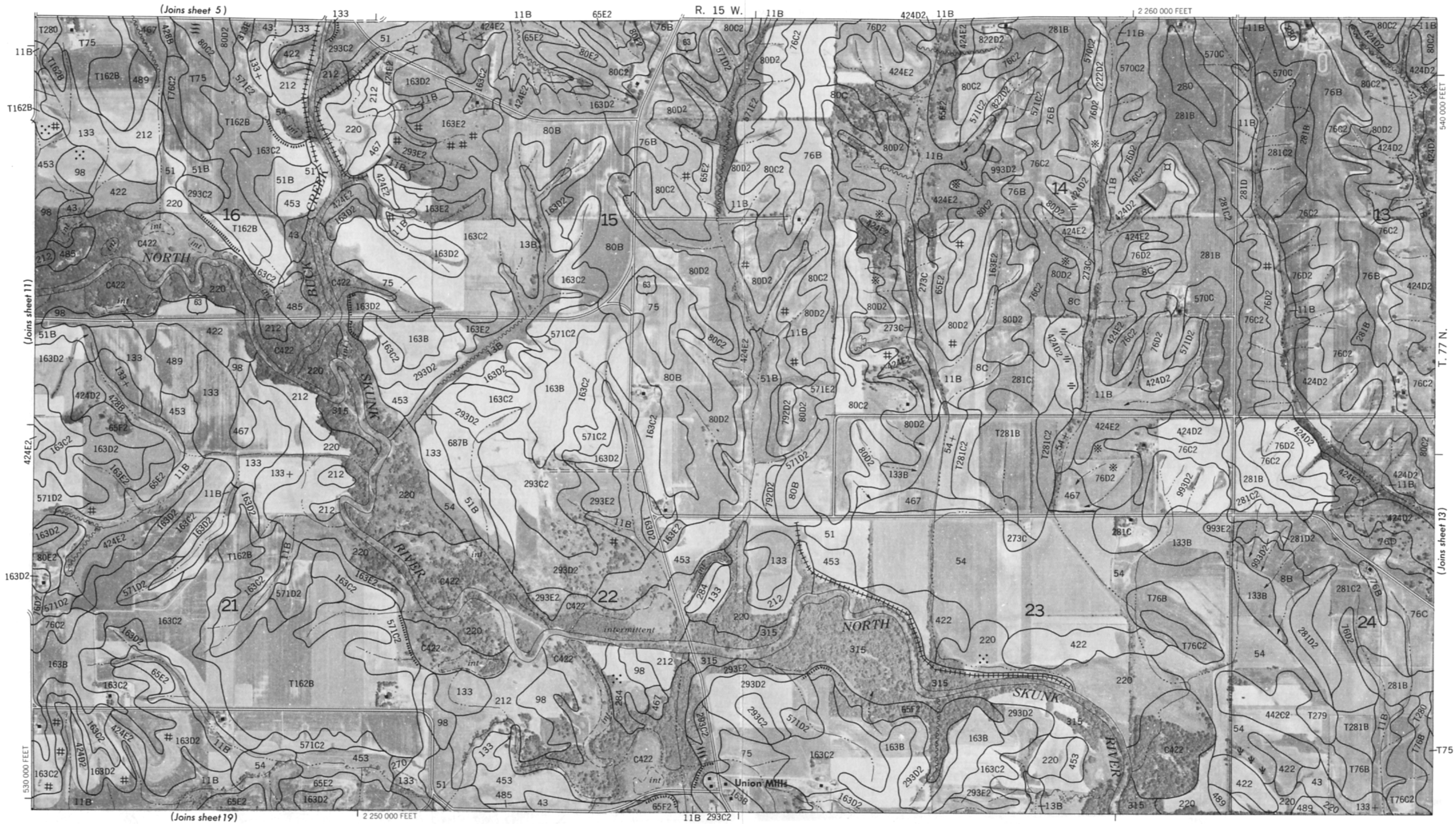

MAHASKA COUNTY, IOWA — SHEET NUMBER 13

13

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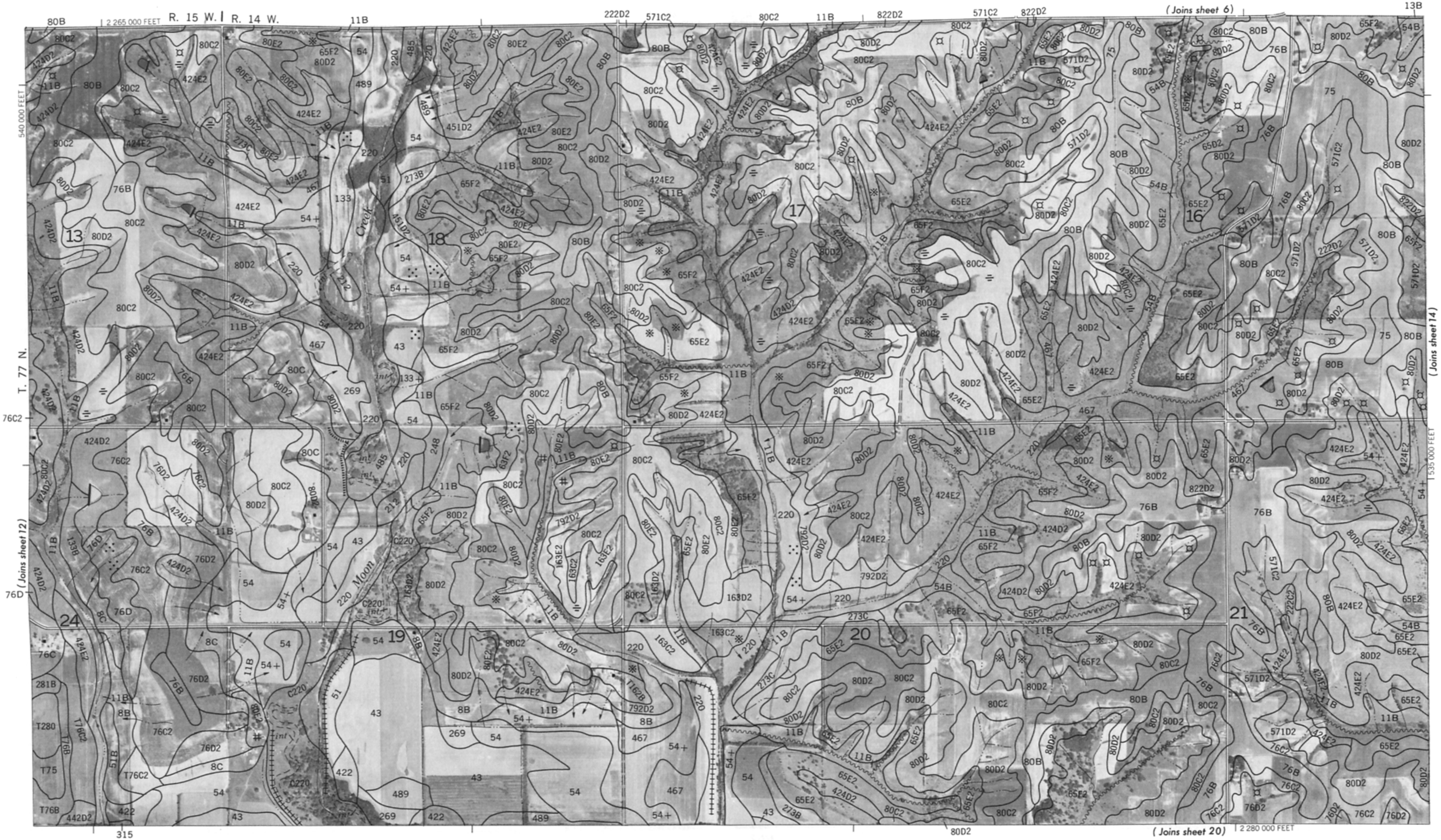
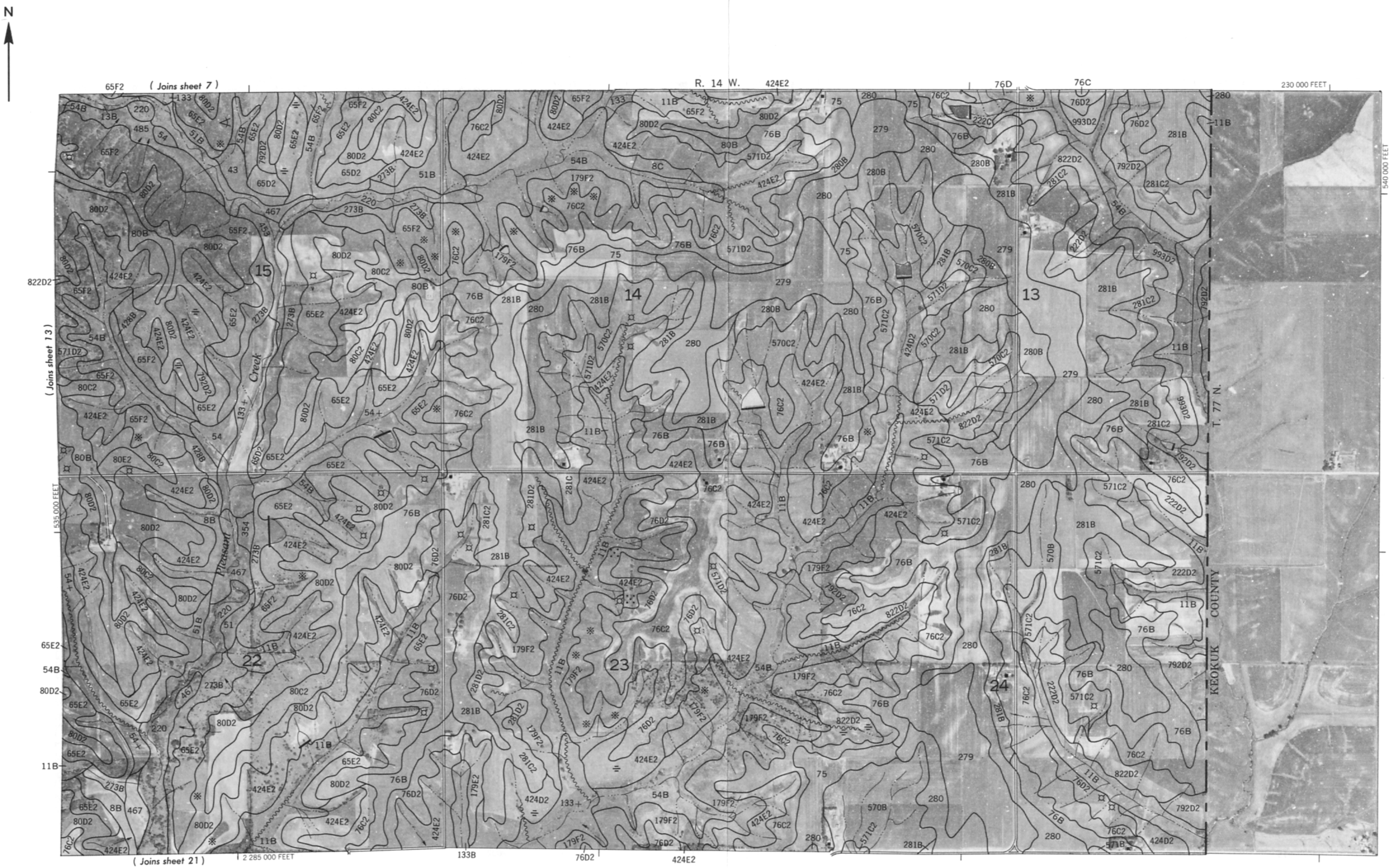


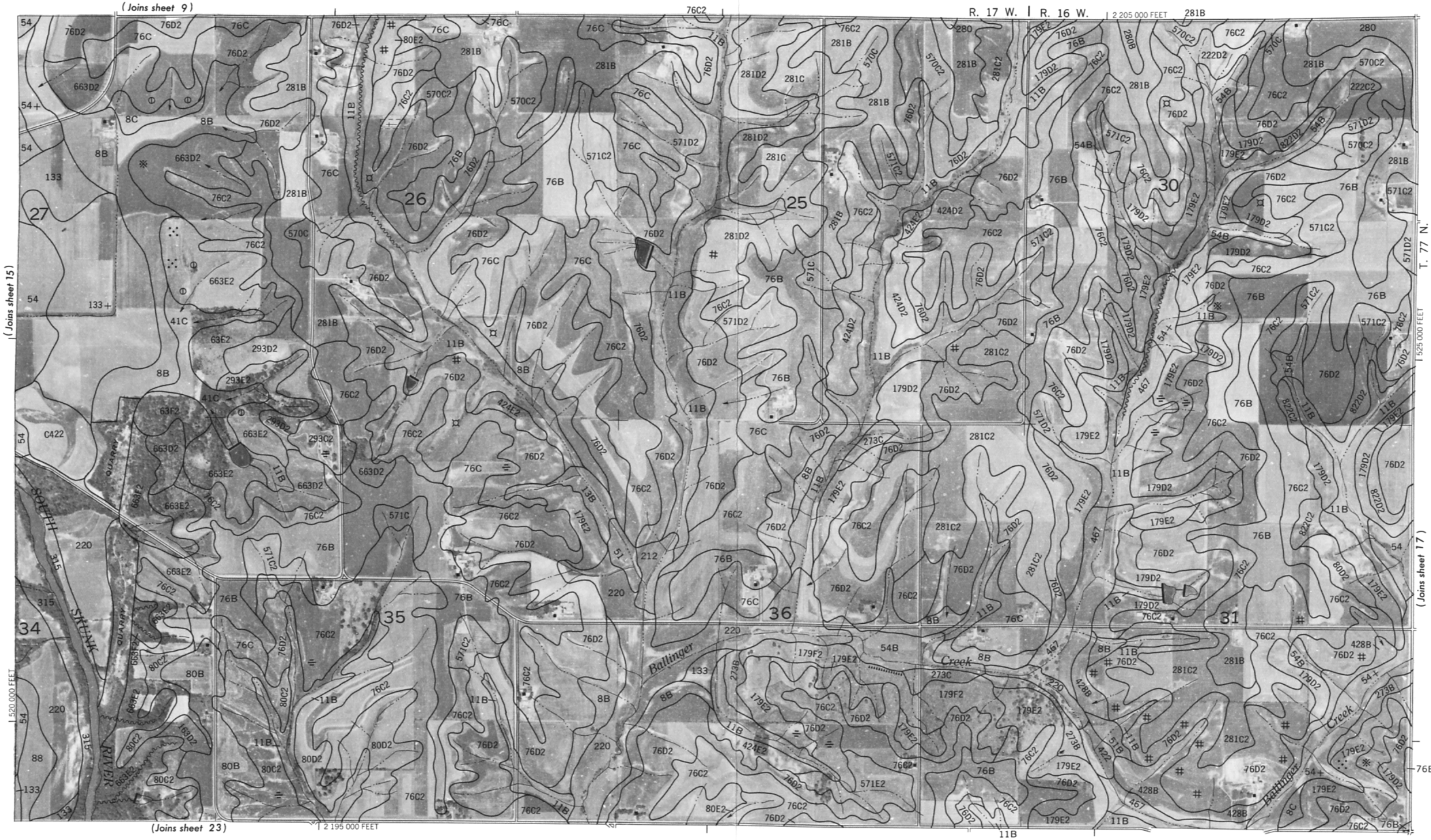
MAHASKA COUNTY, IOWA — SHEET NUMBER 14



N

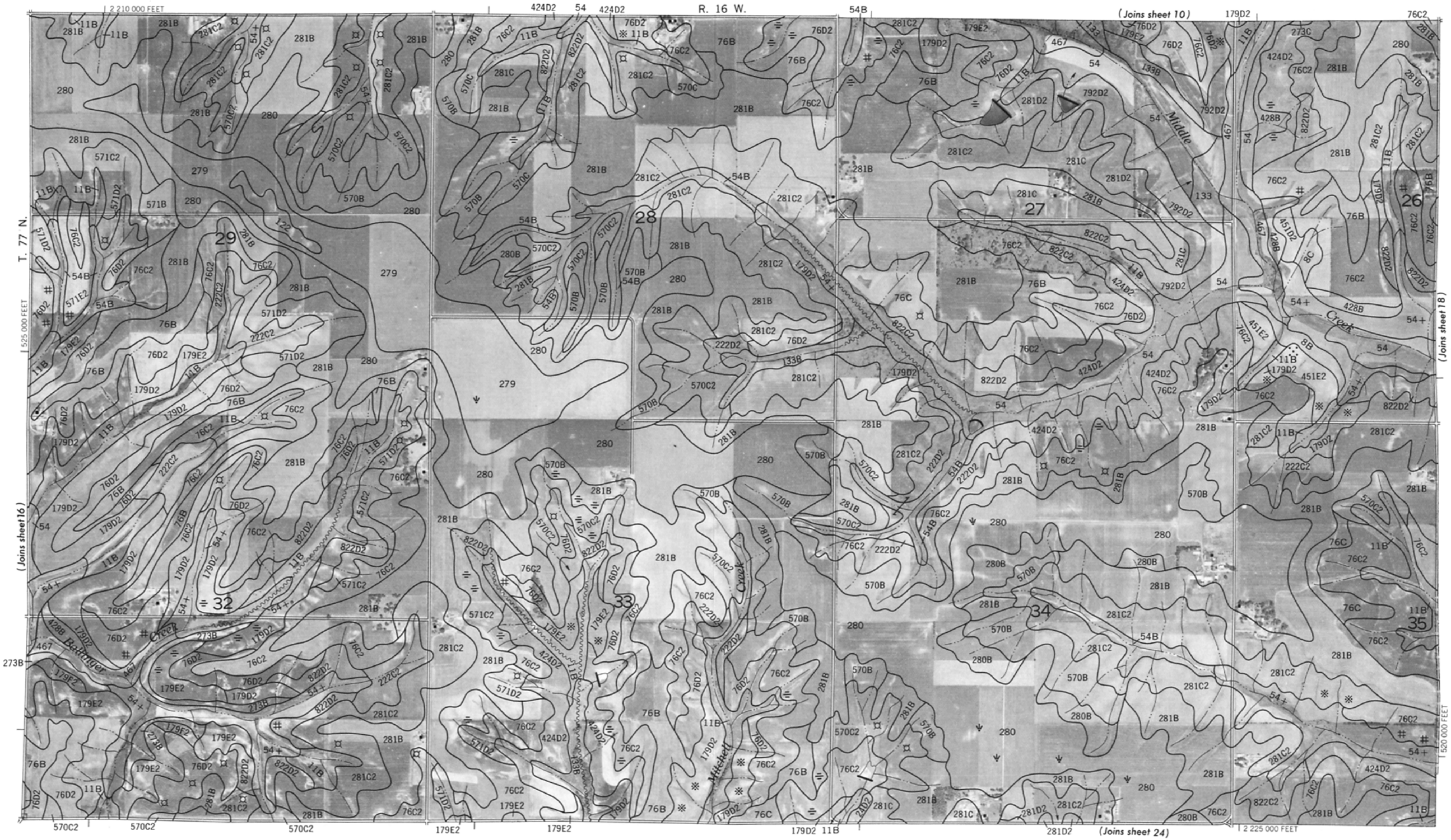

2 175 000 FEET
R. 17 W.
(Joins sheet 8)
(Joins sheet 16)
(Joins sheet 22)
2 190 000 FEET
525 000 FEET
520 000 FEET
T. 77 N.
MARION COUNTY
SOUTH SKUNK RIVER
Buckley Creek
QUARRY
29
30
28
27
31
32
33
34

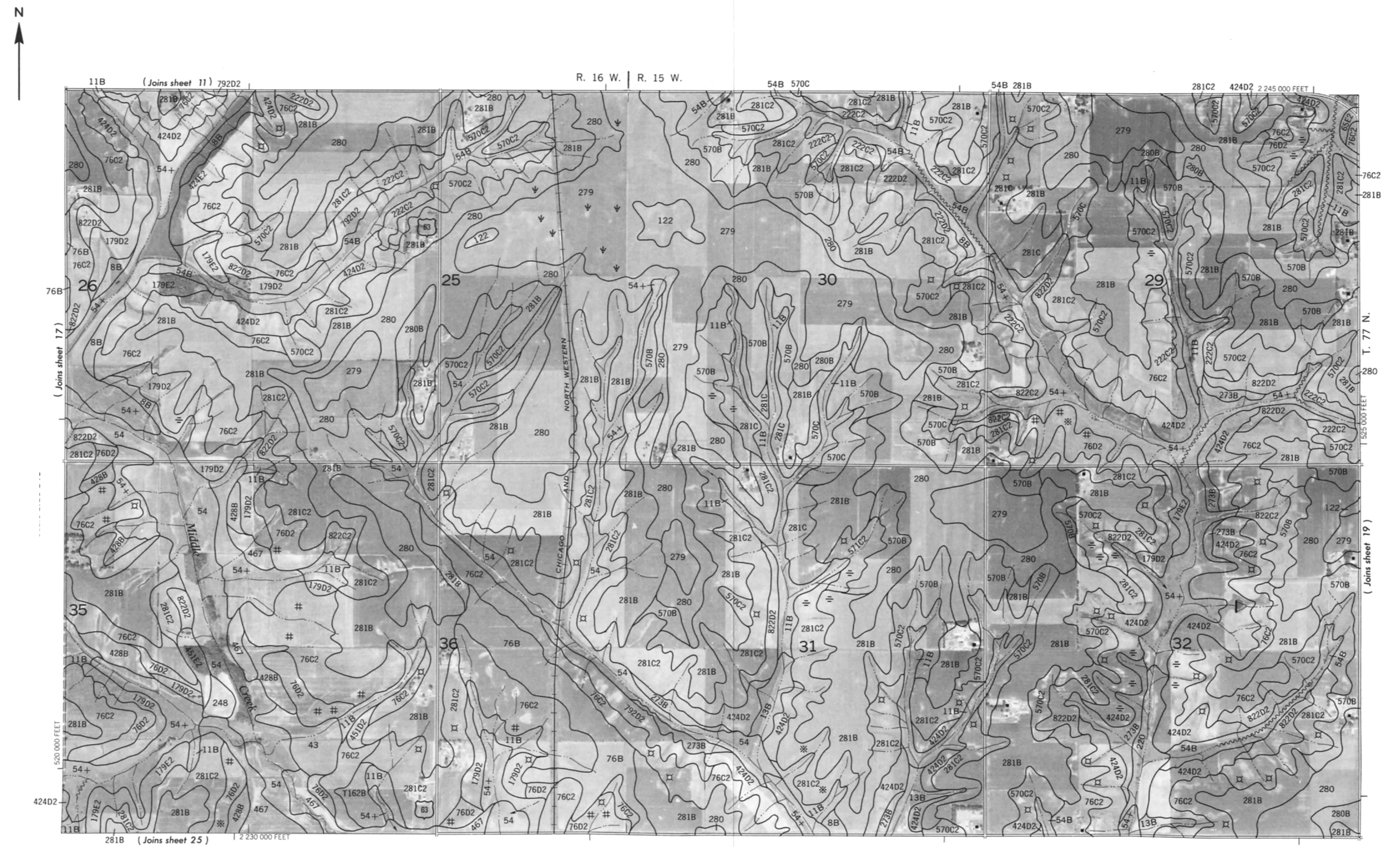
N


(Joins sheet 9)
R. 17 W.
R. 16 W.
2 205 000 FEET
T. 77 N.
525 000 FEET
(Joins sheet 15)
(Joins sheet 17)
520 000 FEET
2 195 000 FEET
(Joins sheet 23)
27
26
25
30
34
35
36
31
SOUTH SKUNK RIVER
QUARRY
Ballinger Creek

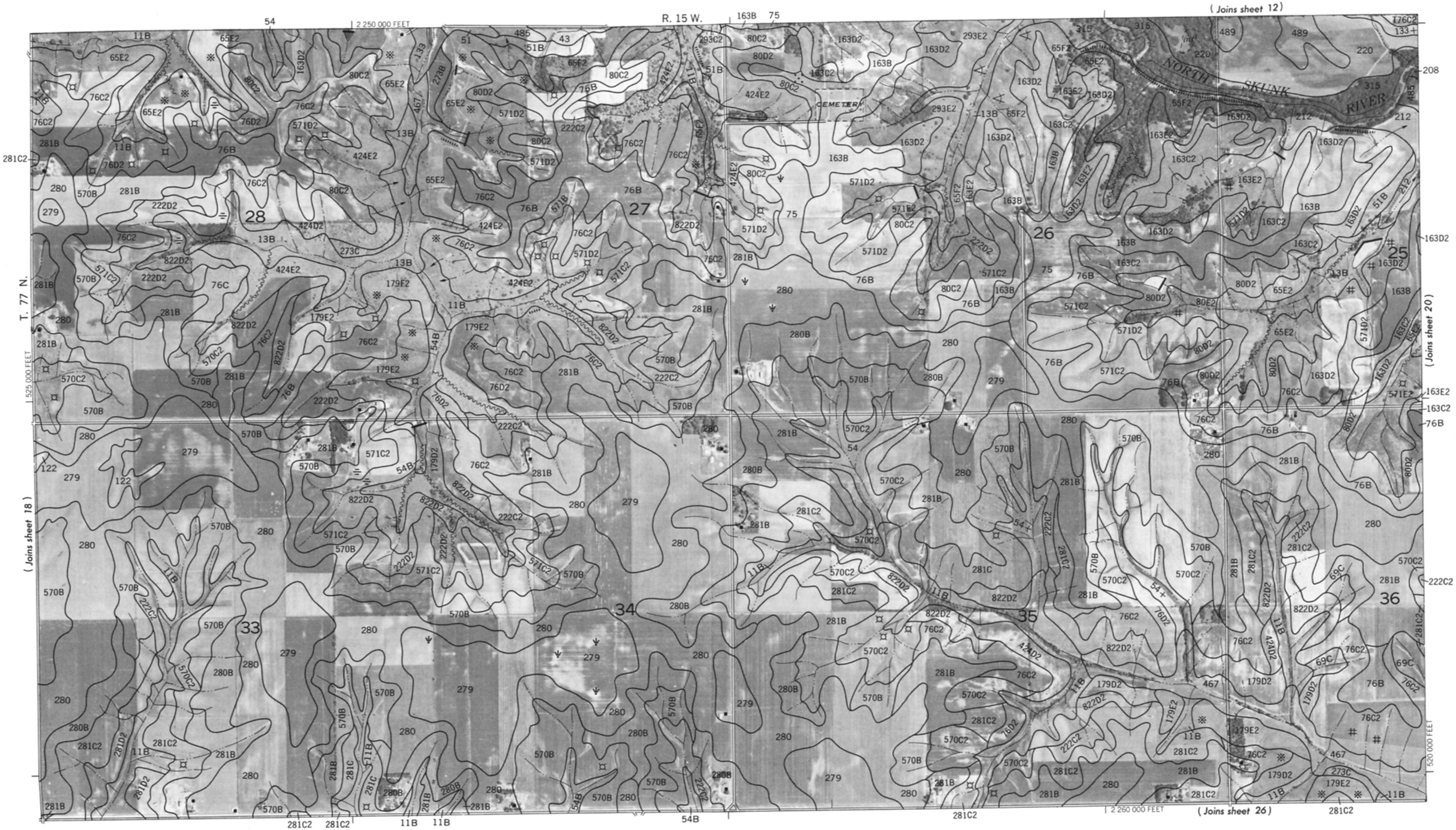
17

N

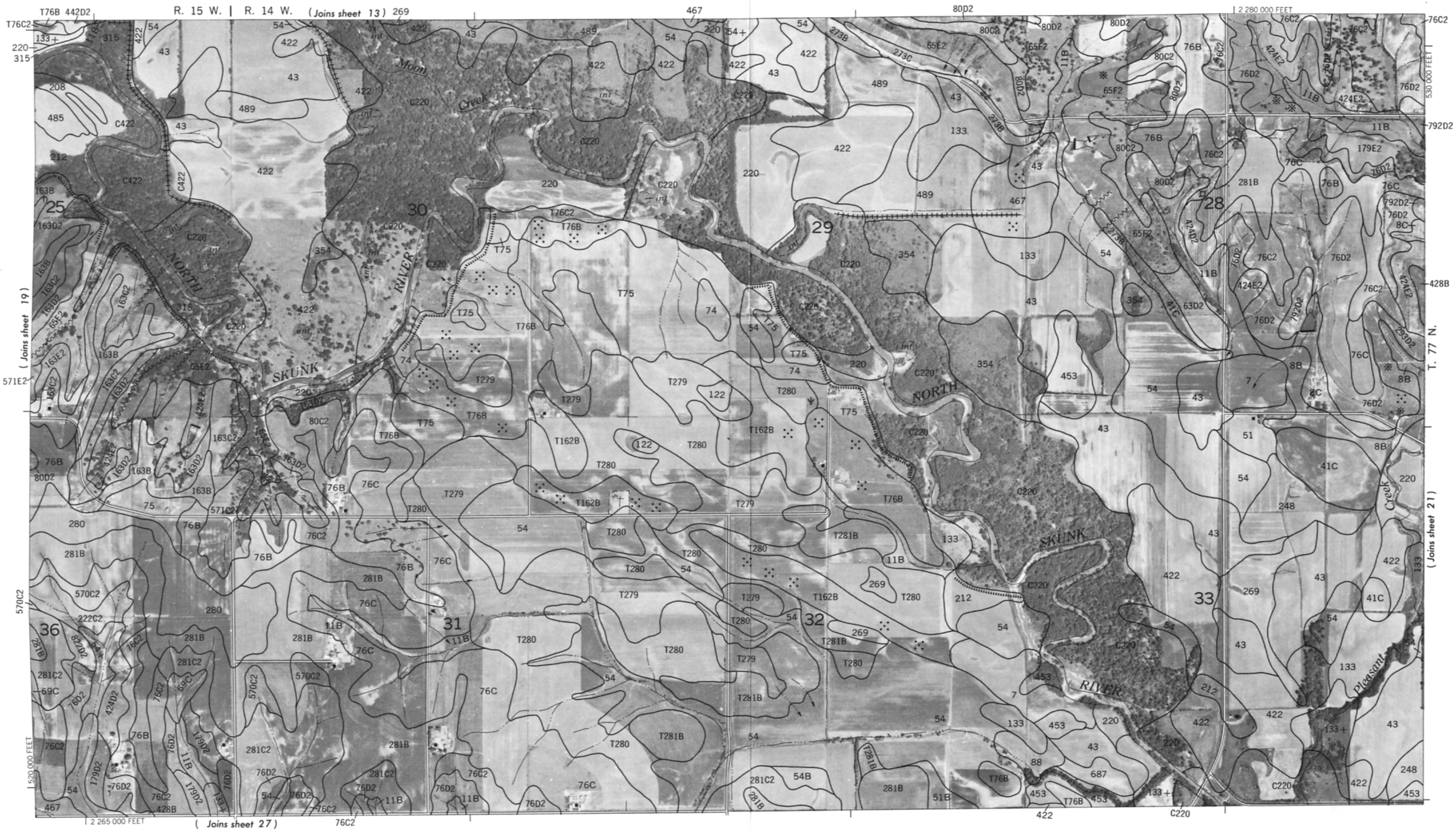

(Joins sheet 10)
(Joins sheet 16)
(Joins sheet 18)
(Joins sheet 24)
R. 16 W.
T. 77 N.
2 210 000 FEET
2 225 000 FEET
525 000 FEET
520 000 FEET
Middle
Creek
Ballinger
Creek
Mitchell
Creek
26
27
28
29
32
33
34
35


N
(Joins sheet 11)
R. 16 W. | R. 15 W.
2 245 000 FEET
(Joins sheet 17)
T. 77 N.
525 000 FEET
(Joins sheet 19)
520 000 FEET
(Joins sheet 25)
2 230 000 FEET
26
25
30
29
35
36
31
32
CHICAGO AND NORTH WESTERN
Middle Creek
63

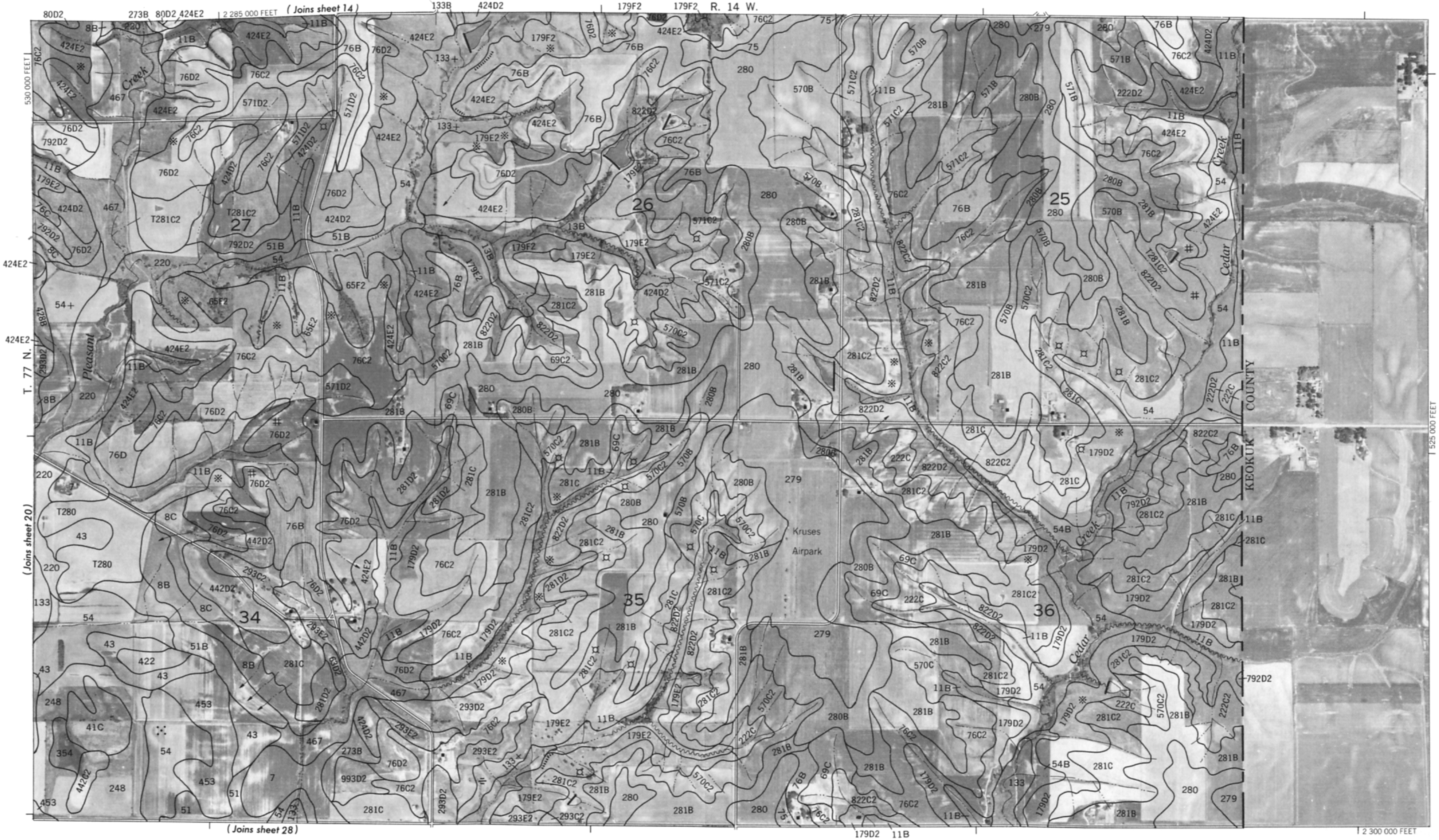
N

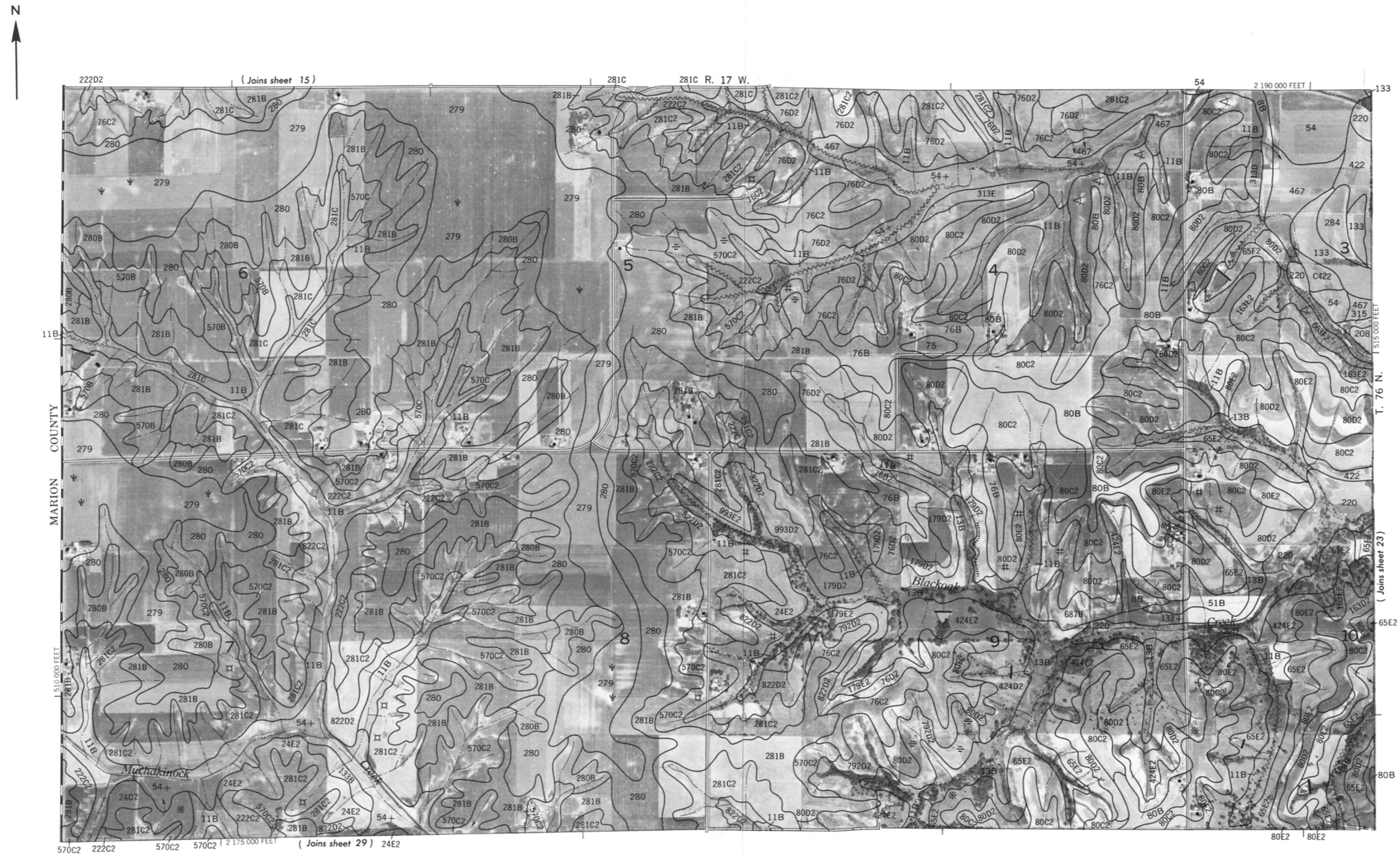

(Joins sheet 12)
(Joins sheet 18)
(Joins sheet 20)
(Joins sheet 26)
R. 15 W.
T. 77 N.
2 250 000 FEET
2 260 000 FEET
525 000 FEET
520 000 FEET
NORTH SKUNK RIVER
CEMETERY
25
26
27
28
33
34
35
36

N


R. 15 W. | R. 14 W.
(Joins sheet 13)
(Joins sheet 19)
(Joins sheet 21)
(Joins sheet 27)
T. 77 N.
2 280 000 FEET
530 000 FEET
2 265 000 FEET
520 000 FEET
NORTH SKUNK RIVER
Moon Creek
Pleasant Creek
25
28
29
30
31
32
33
36

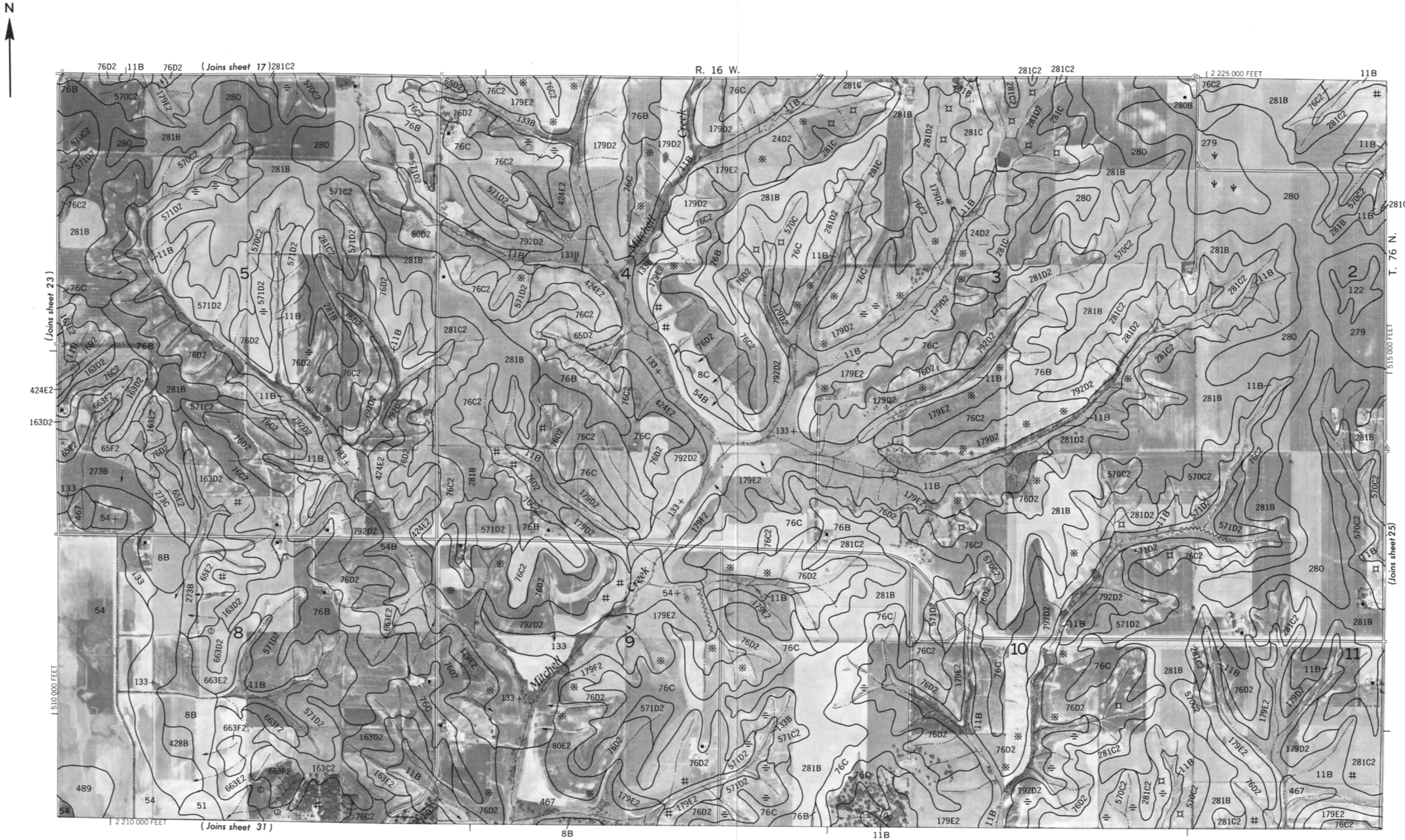
N


(Joins sheet 14)
2 285 000 FEET
R. 14 W.
530 000 FEET
T. 77 N.
(Joins sheet 20)
(Joins sheet 28)
525 000 FEET
2 300 000 FEET
KEOKUK COUNTY
Pleasant
Creek
Cedar
Creek
Kruses
Airpark
27
26
25
34
35
36


N
(Joins sheet 15)
R. 17 W.
2 190 000 FEET
515 000 FEET
T. 76 N.
(Joins sheet 23)
MARION COUNTY
510 000 FEET
2 175 000 FEET
(Joins sheet 29)
Muchakinock
Creek
Blackoak
Creek

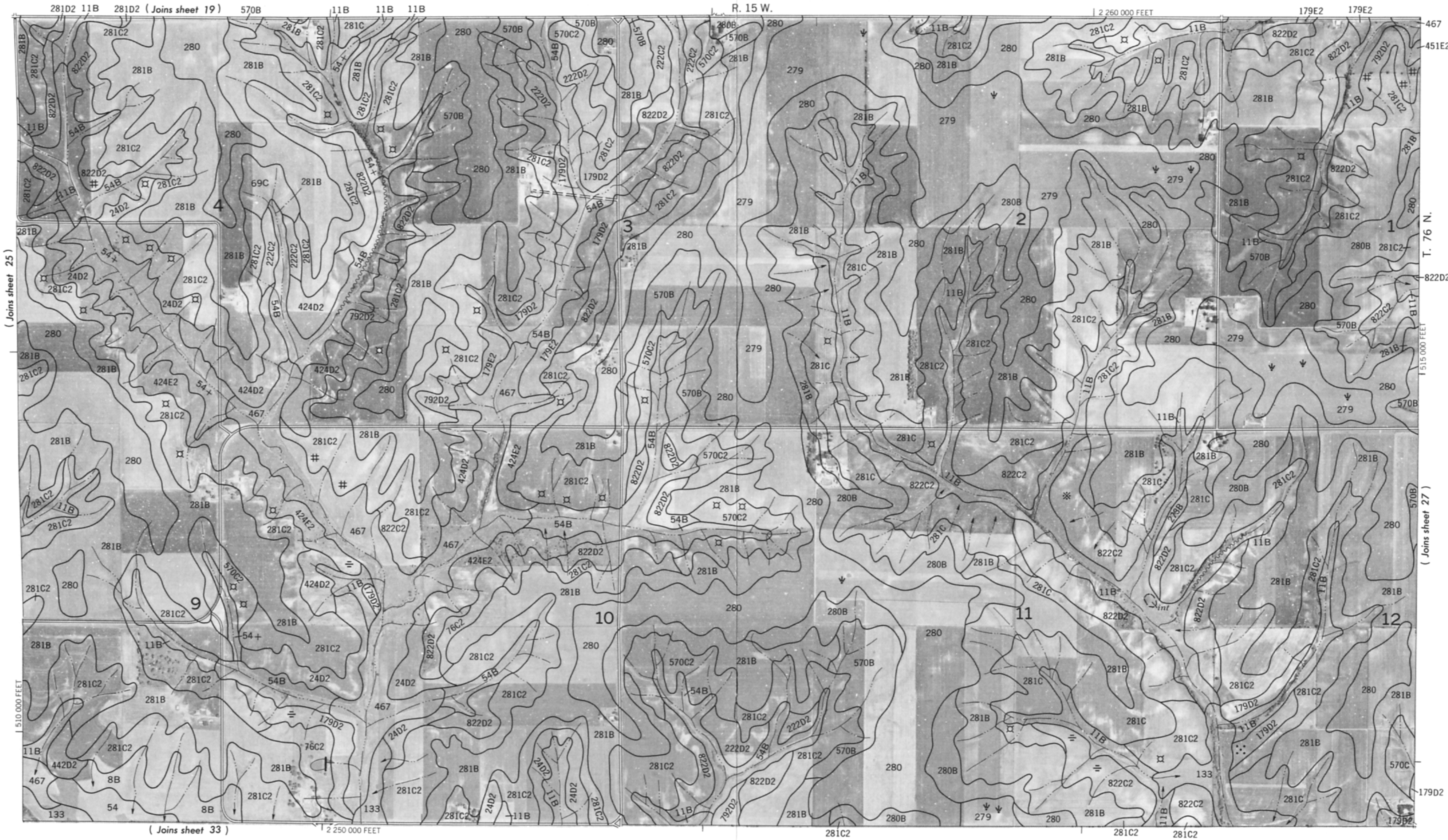
N


R. 17 W. | R. 16 W.
(Joins sheet 16)
(Joins sheet 22)
(Joins sheet 24)
(Joins sheet 30)
T. 76 N.
2 195 000 FEET
2 205 000 FEET
515 000 FEET
510 000 FEET
SOUTH SKUNK RIVER
Ballinger Creek
Blackoak Creek
QUARRY
intermittent

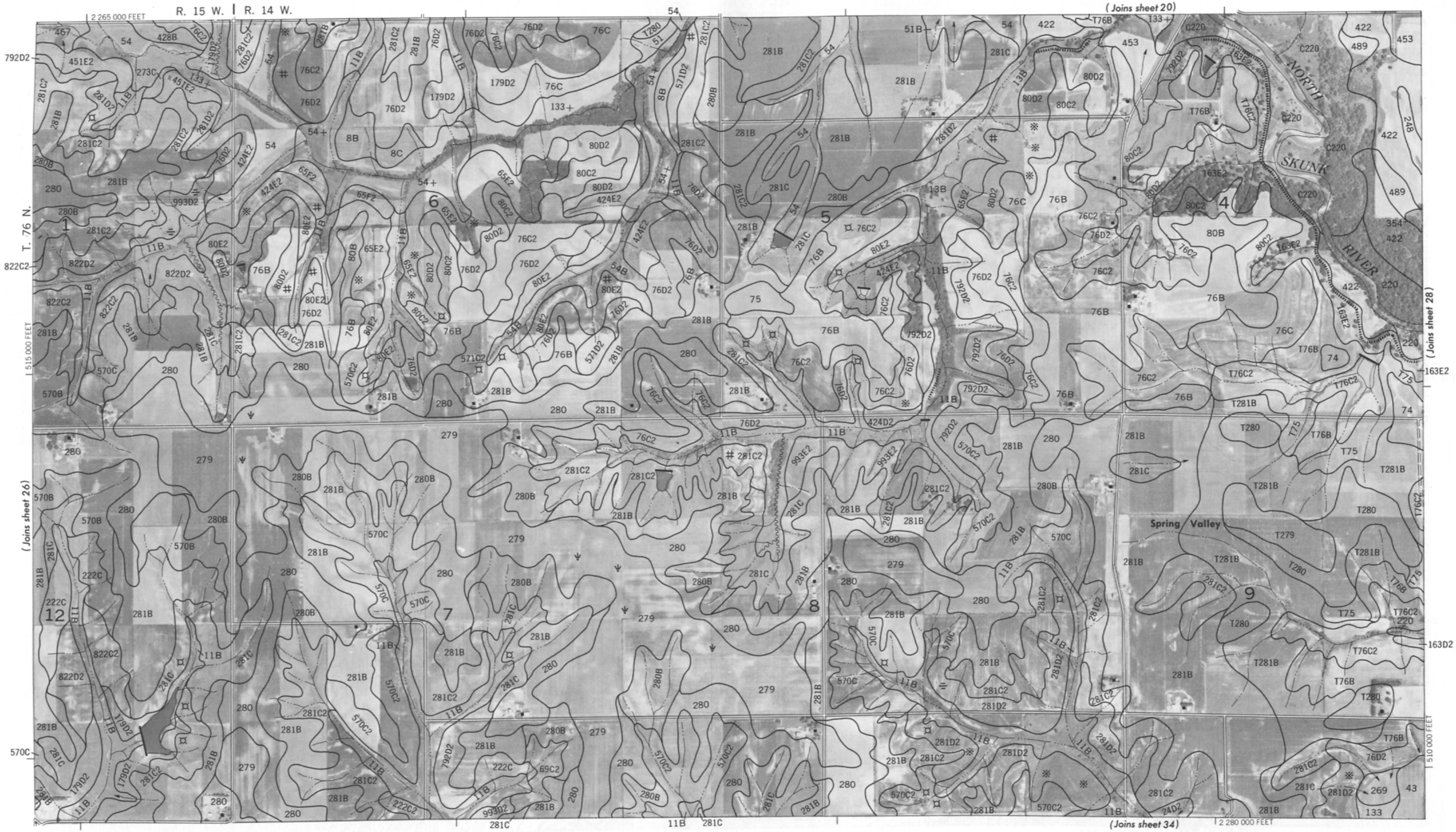

N
(Joins sheet 17)
R. 16 W.
2 225 000 FEET
T. 76 N.
515 000 FEET
(Joins sheet 23)
(Joins sheet 25)
510 000 FEET
2 210 000 FEET
(Joins sheet 31)
Mitchell Creek
Creek
Mitchell
1
2
3
4
5
8
9
10
11


N
R. 16 W.
R. 15 W.
T. 76 N.
(Joins sheet 18)
(Joins sheet 26)
(Joins sheet 24)
(Joins sheet 32)
2 230 000 FEET
2 245 000 FEET
515 000 FEET
510 000 FEET
Middle Creek
CHICAGO AND NORTH WESTERN
Lacey
63
1
2
5
6
7
8
11
12

N


(Joins sheet 19)
R. 15 W.
2 260 000 FEET
T. 76 N.
515 000 FEET
(Joins sheet 25)
(Joins sheet 27)
510 000 FEET
(Joins sheet 33)
2 250 000 FEET
1
2
3
4
9
10
11
12

N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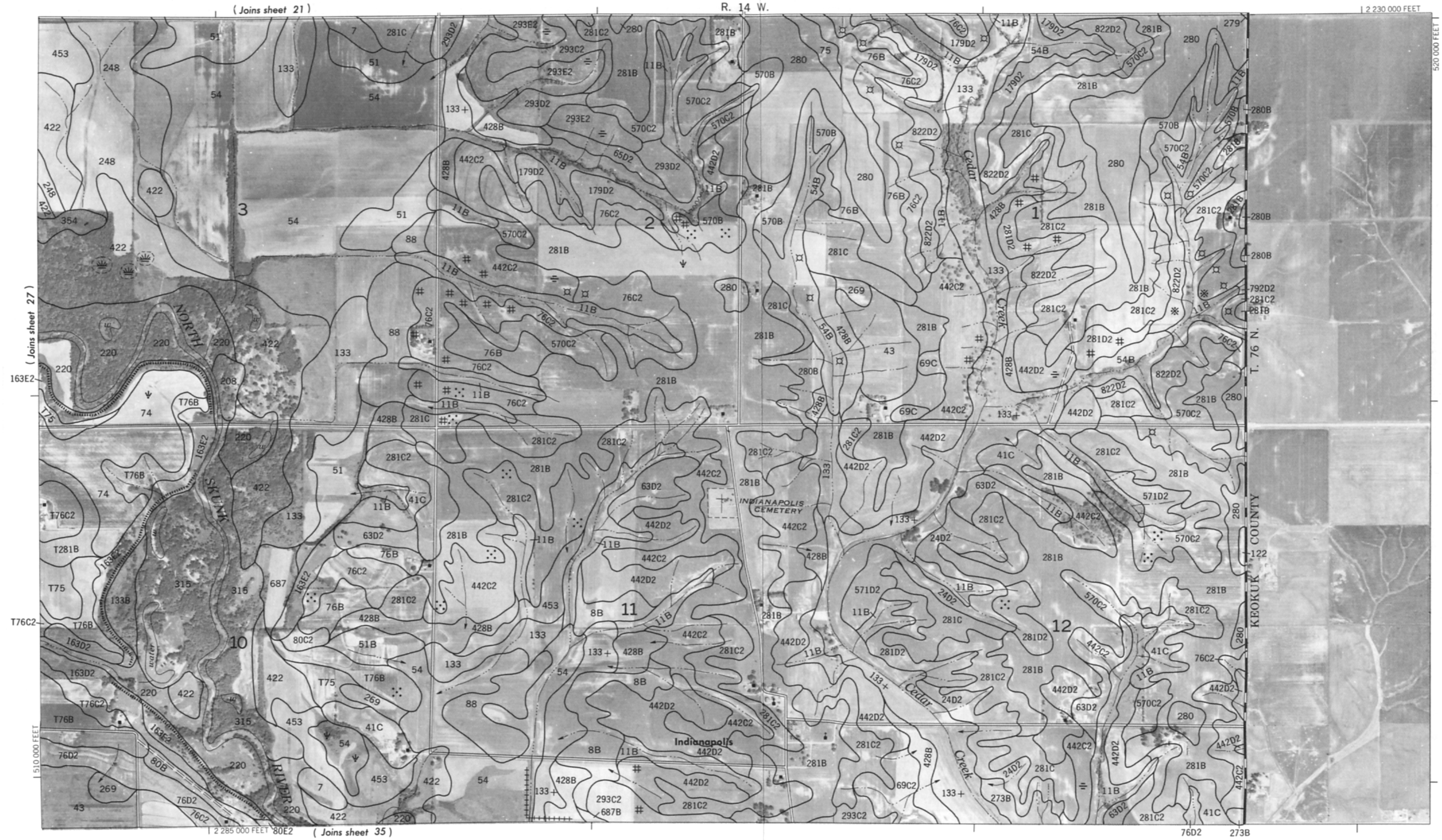
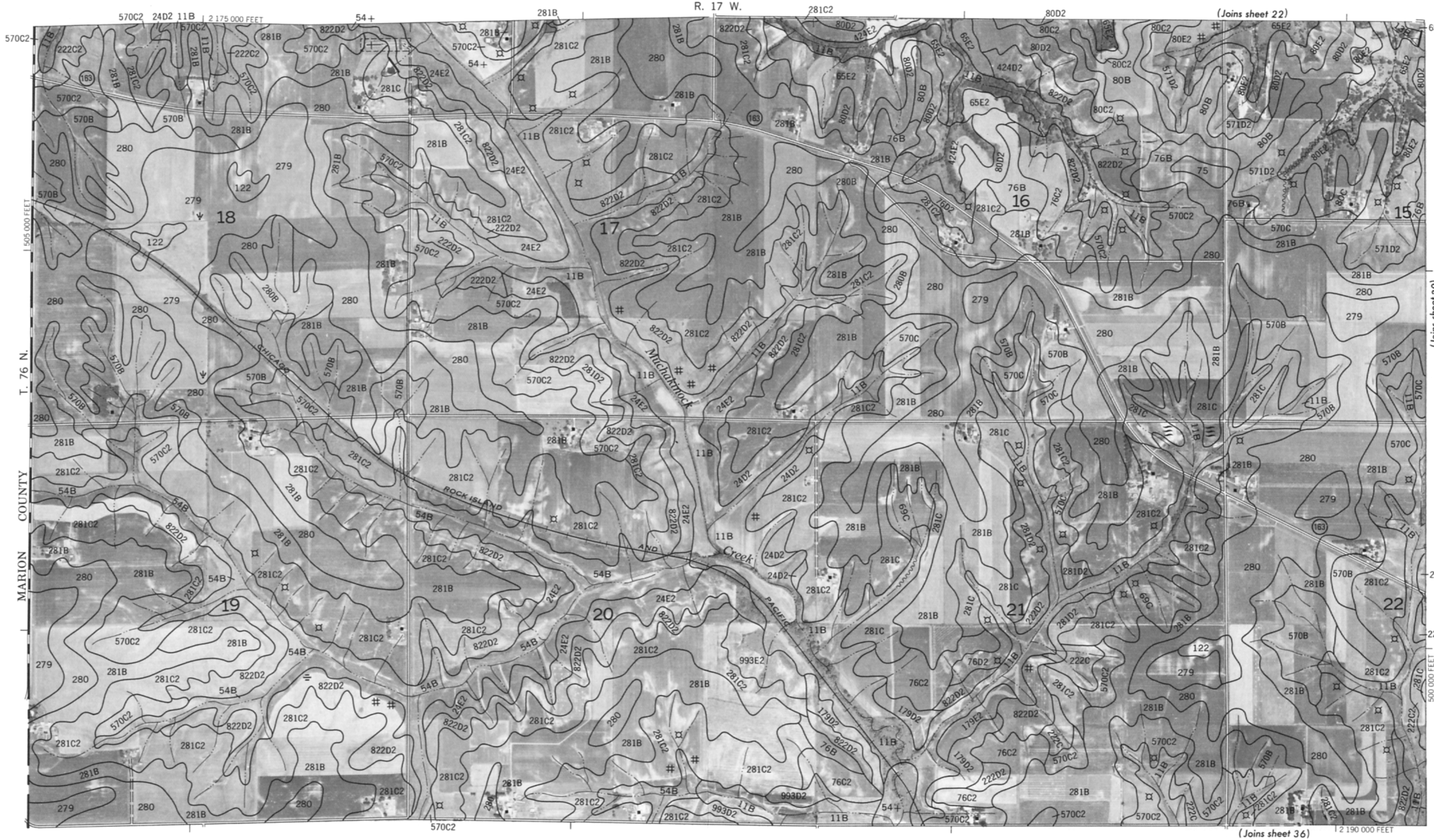
R. 15 W.
R. 14 W.
2 265 000 FEET
T. 76 N.
(Joins sheet 26)
(Joins sheet 28)
(Joins sheet 34)
2 280 000 FEET
515 000 FEET
510 000 FEET
NORTH SKUNK RIVER
Spring Valley

28

N


(Joins sheet 21)
R. 14 W.
2 230 000 FEET
520 000 FEET
T. 76 N.
KEOKUK COUNTY
(Joins sheet 27)
NORTH SKUNK RIVER
Cedar Creek
INDIANAPOLIS CEMETERY
Indianapolis
510 000 FEET
2 285 000 FEET
(Joins sheet 35)

N


R. 17 W.
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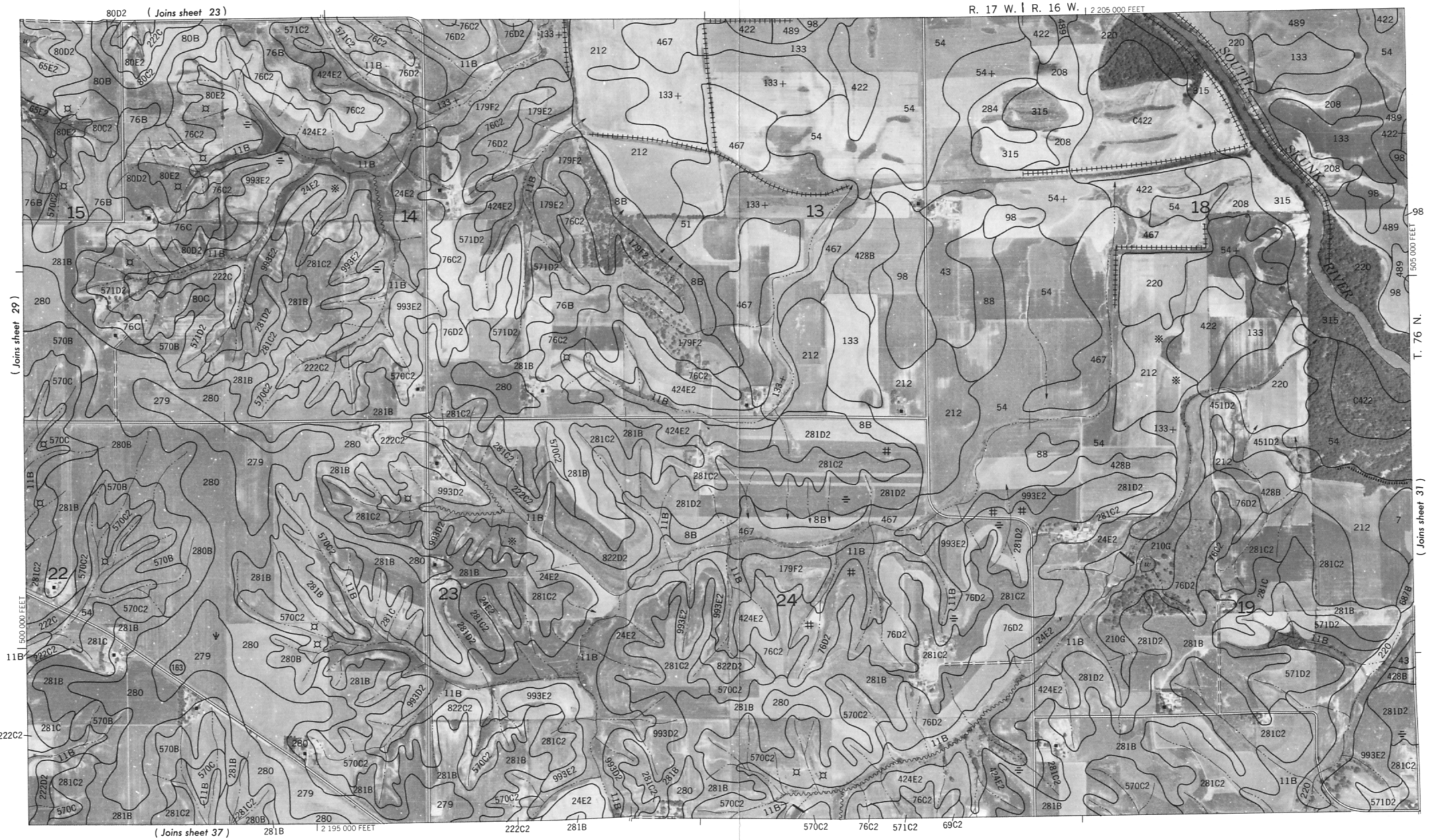
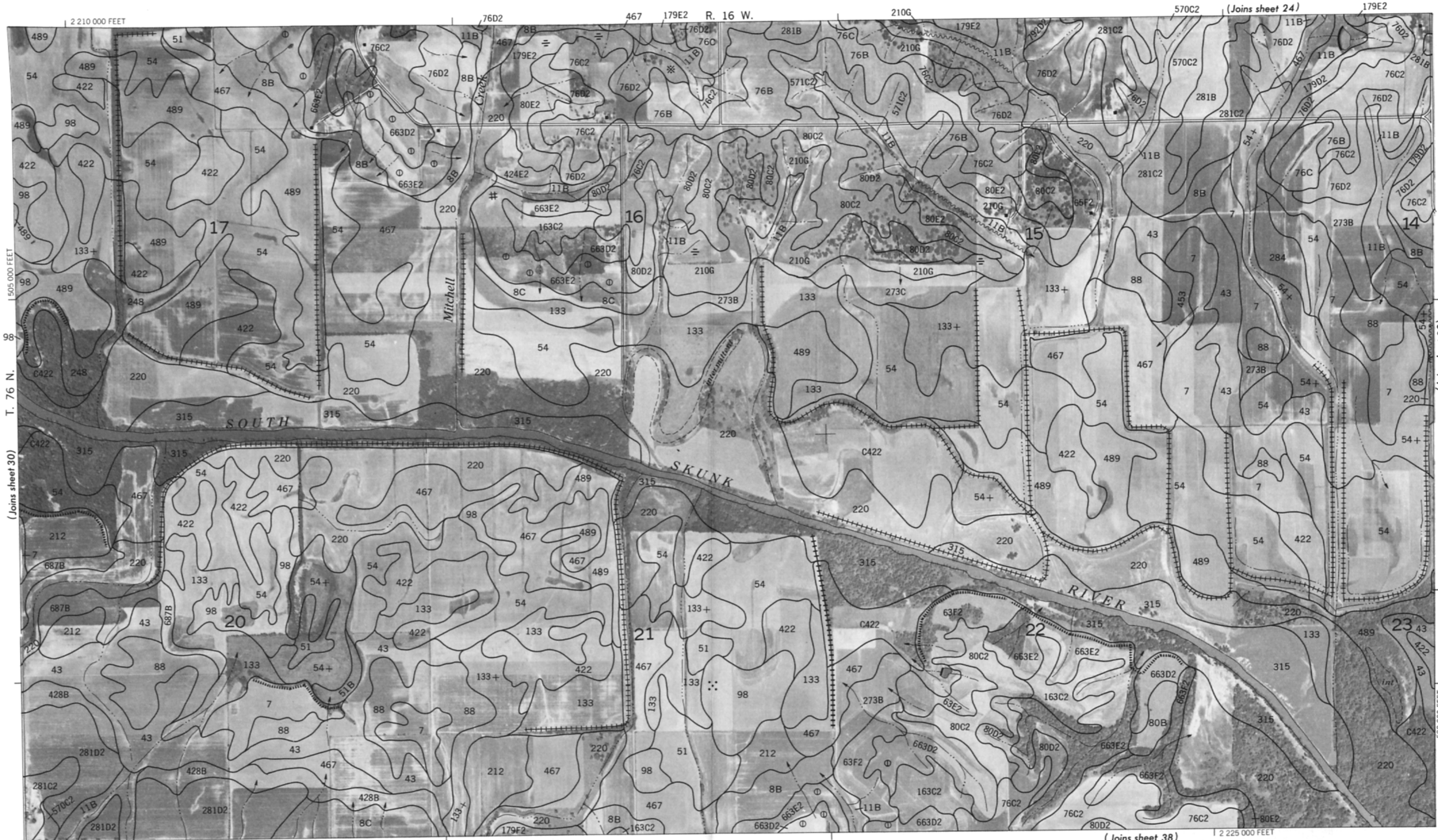
(Joins sheet 30)
(Joins sheet 36)
T. 76 N.
MARION COUNTY
2 175 000 FEET
2 190 000 FEET
505 000 FEET
500 000 FEET
Muchakinock Creek
CHICAGO ROCK ISLAND AND PACIFIC
15
16
17
18
19
20
21
22

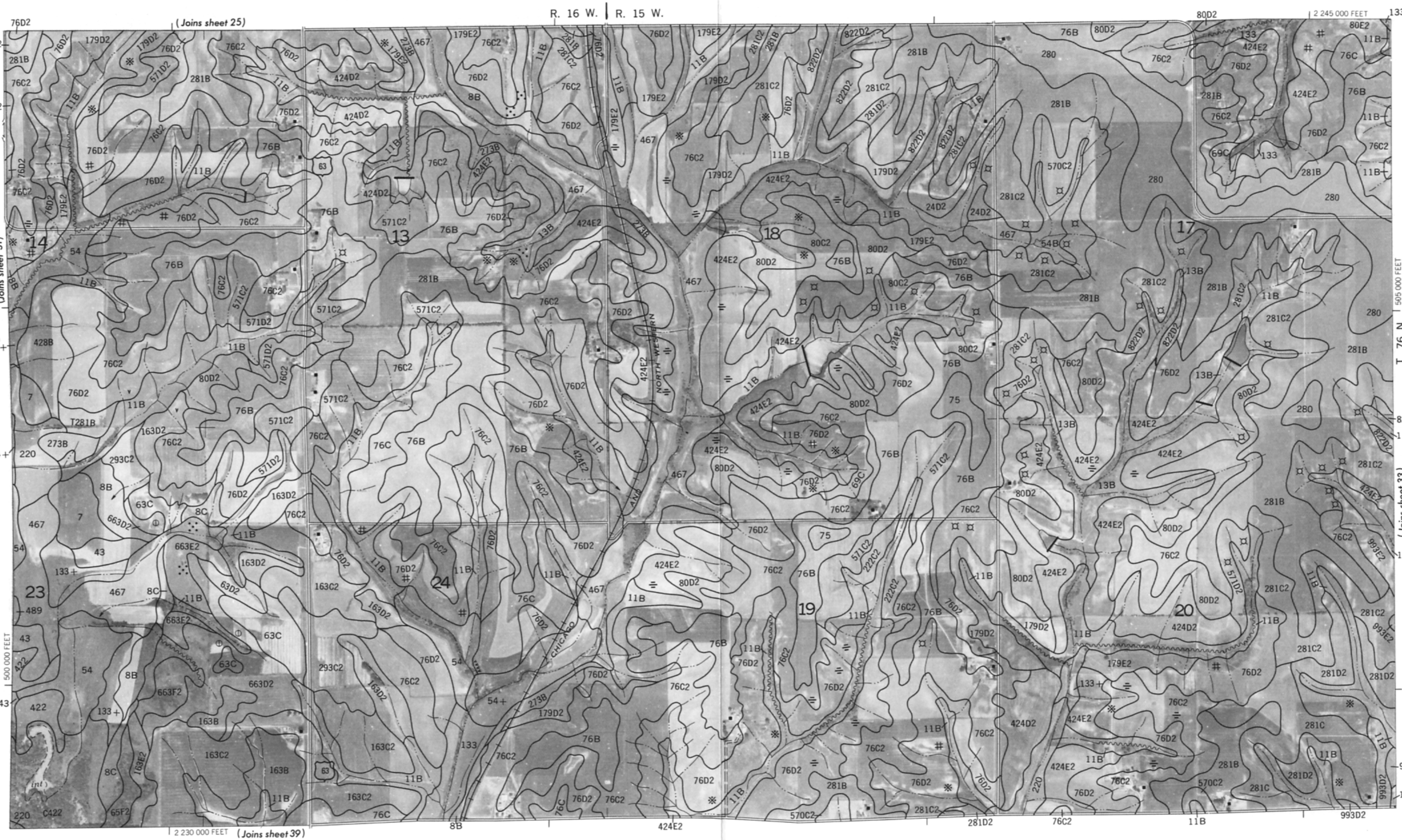
N

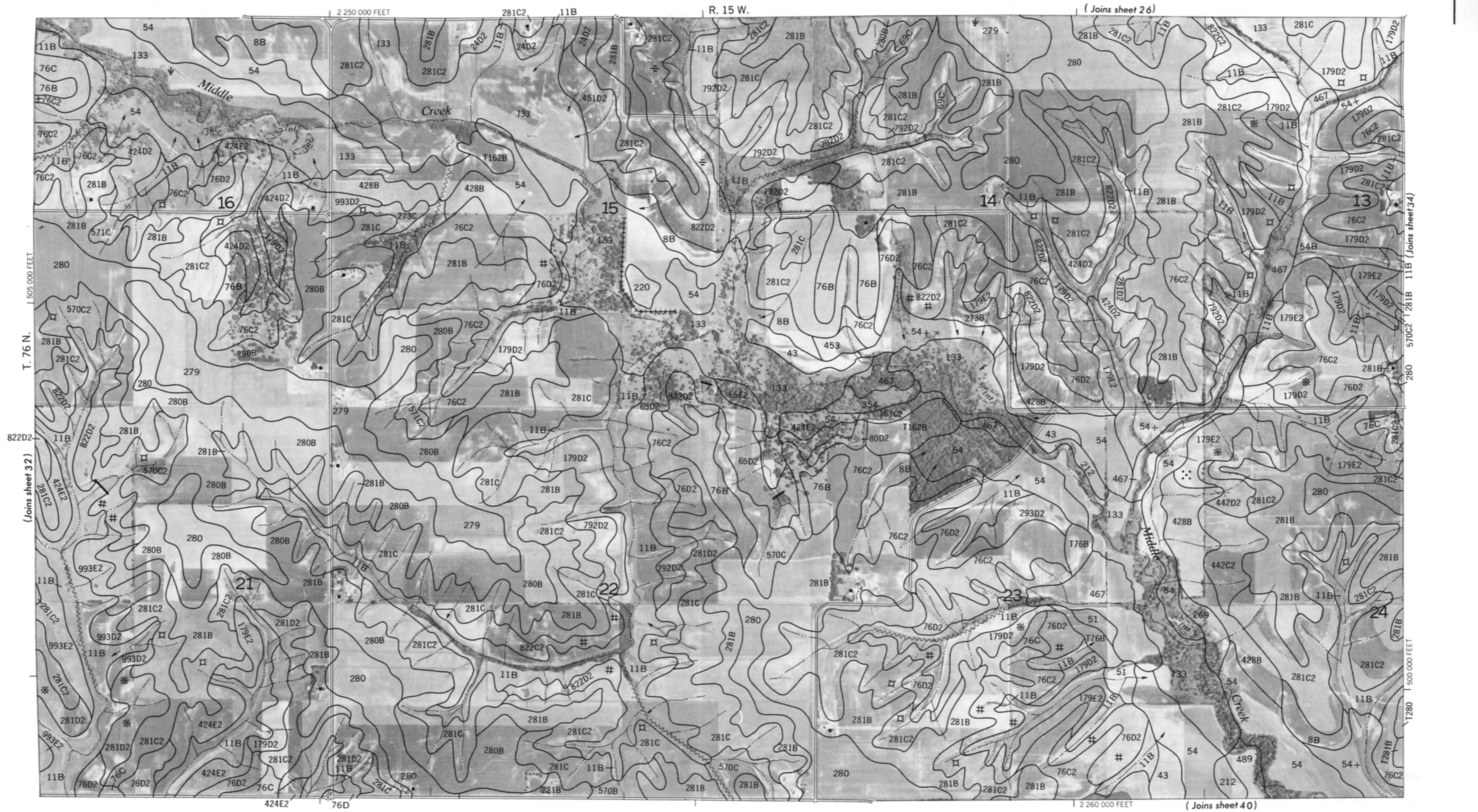

(Joins sheet 23)
R. 17 W. | R. 16 W.
2 205 000 FEET
(Joins sheet 29)
(Joins sheet 31)
505 000 FEET
T. 76 N.
500 000 FEET
(Joins sheet 37)
2 195 000 FEET
SOUTH SKUNK RIVER
15
14
13
18
22
23
24
19
163

N


2 210 000 FEET
R. 16 W.
(Joins sheet 24)
(Joins sheet 30)
(Joins sheet 32)
(Joins sheet 38)
T. 76 N.
505 000 FEET
500 000 FEET
2 225 000 FEET
SOUTH
SKUNK
RIVER
Mitchell
Creek
Intermittent
17
16
15
14
20
21
22
23

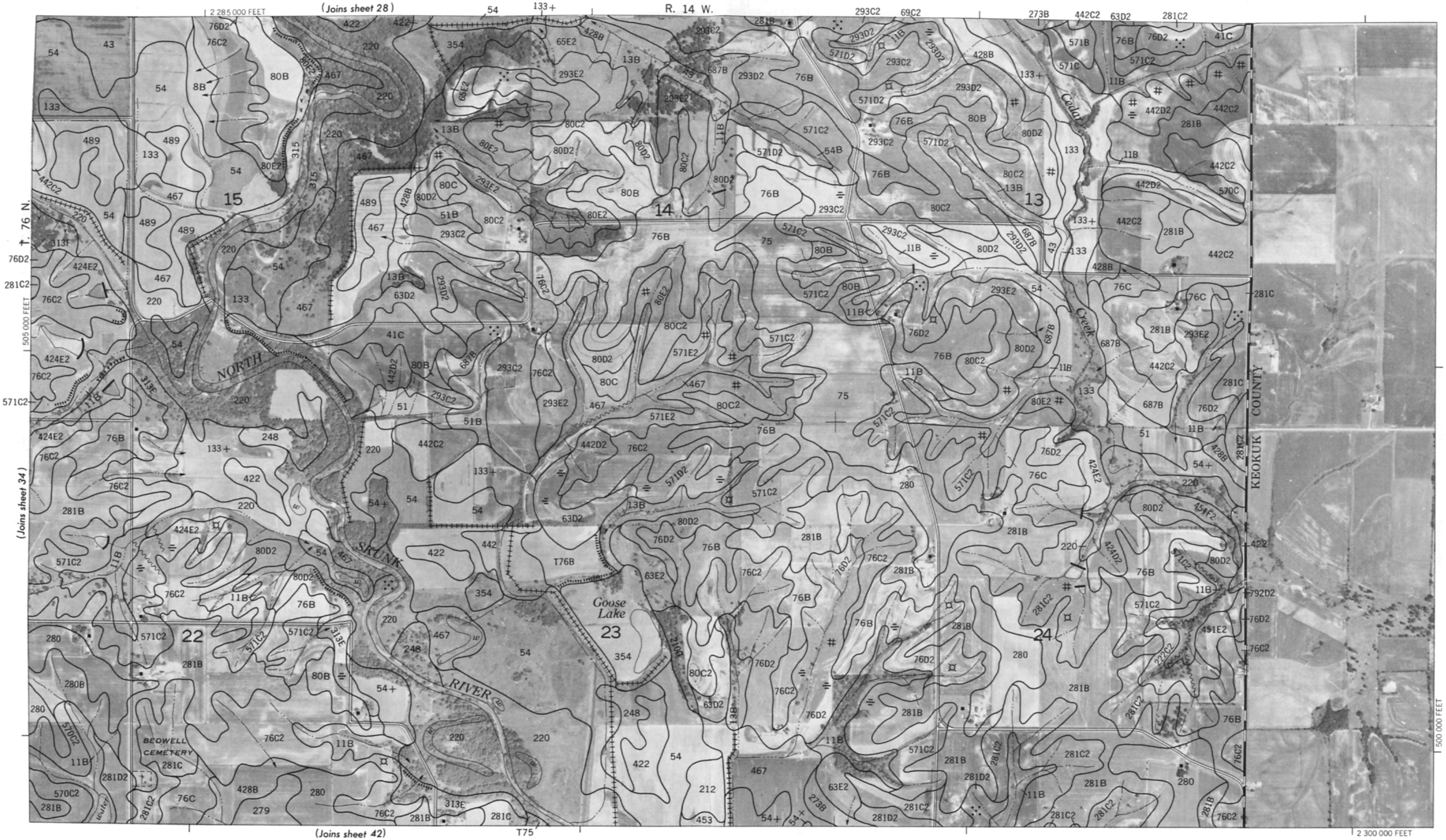
N


R. 16 W.
R. 15 W.
T. 76 N.
(Joins sheet 25)
(Joins sheet 31)
(Joins sheet 33)
(Joins sheet 39)
2 245 000 FEET
505 000 FEET
500 000 FEET
2 230 000 FEET
13
14
17
18
19
20
23
24
NORTH WESTERN
CHICAGO AND
63

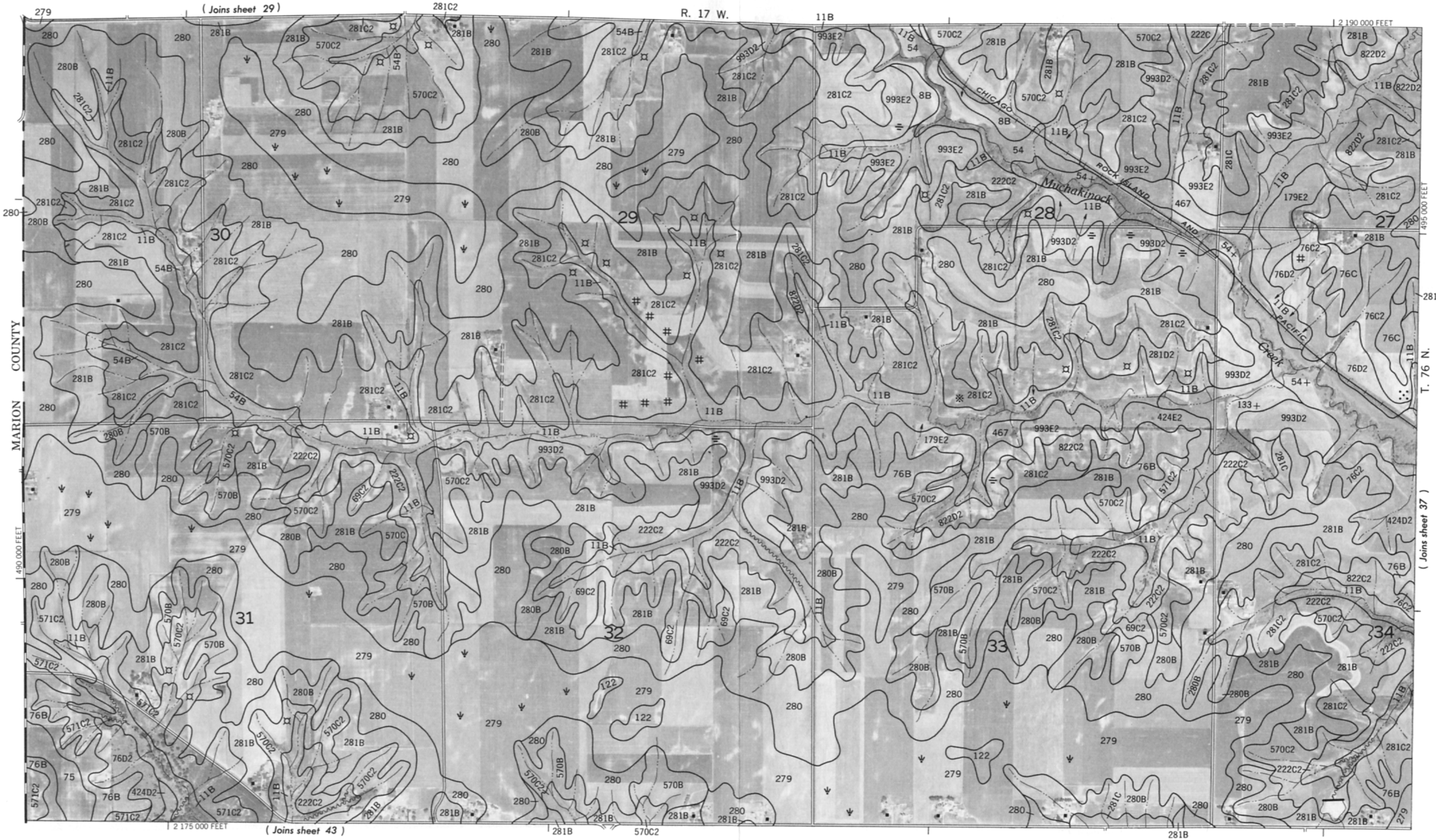

33
N
2 250 000 FEET
R. 15 W.
(Joins sheet 26)
(Joins sheet 34)
(Joins sheet 32)
(Joins sheet 40)
T. 76 N.
505 000 FEET
500 000 FEET
2 260 000 FEET
Middle Creek
16
15
14
13
21
22
23
24

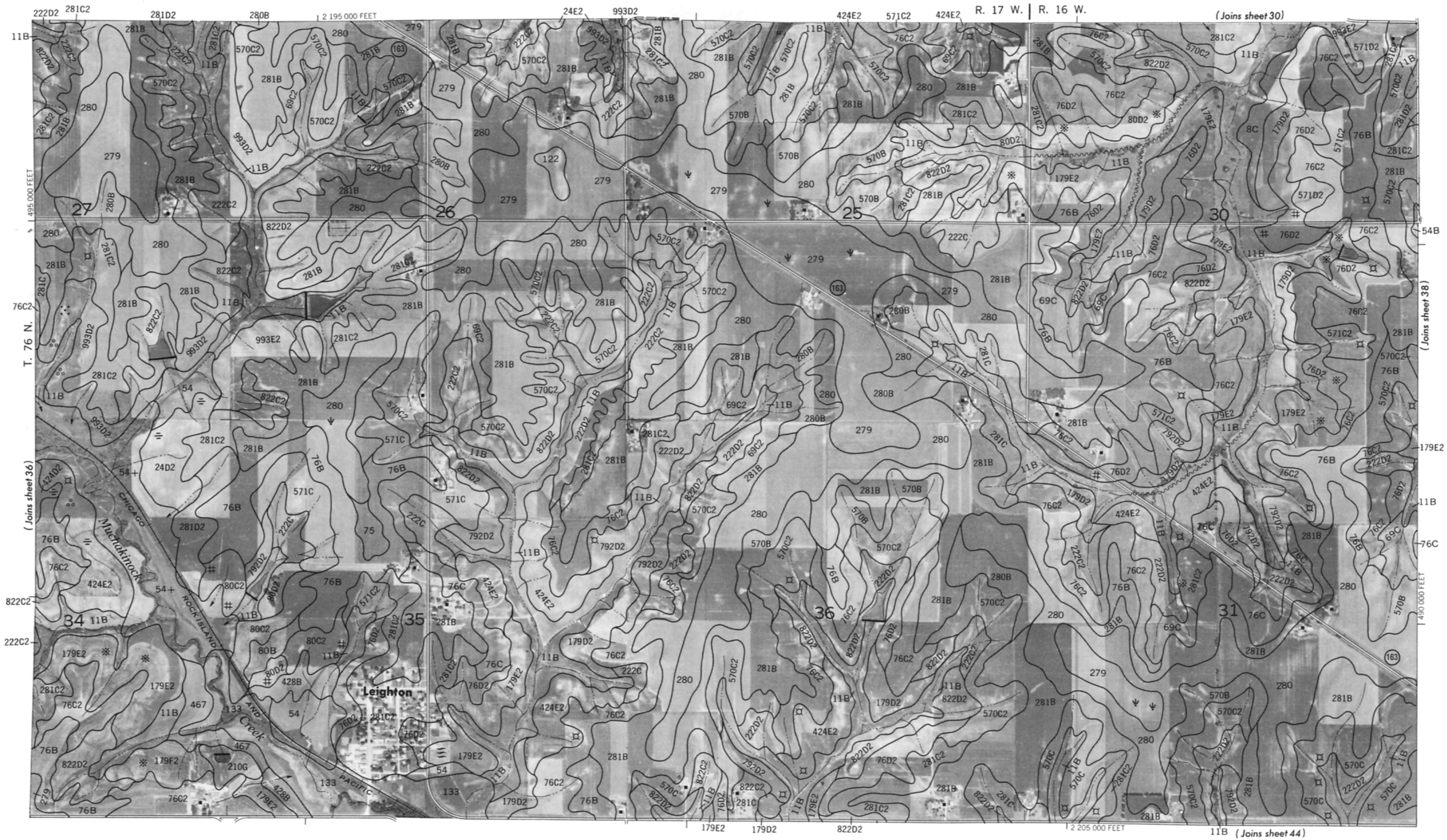

34
N
R. 15 W.
R. 14 W.
(Joins sheet 27)
2 280 000 FEET
(Joins sheet 33)
(Joins sheet 35)
T. 76 N.
505 000 FEET
500 000 FEET
2 265 000 FEET
(Joins sheet 41)
13
18
17
16
24
19
20
21

N

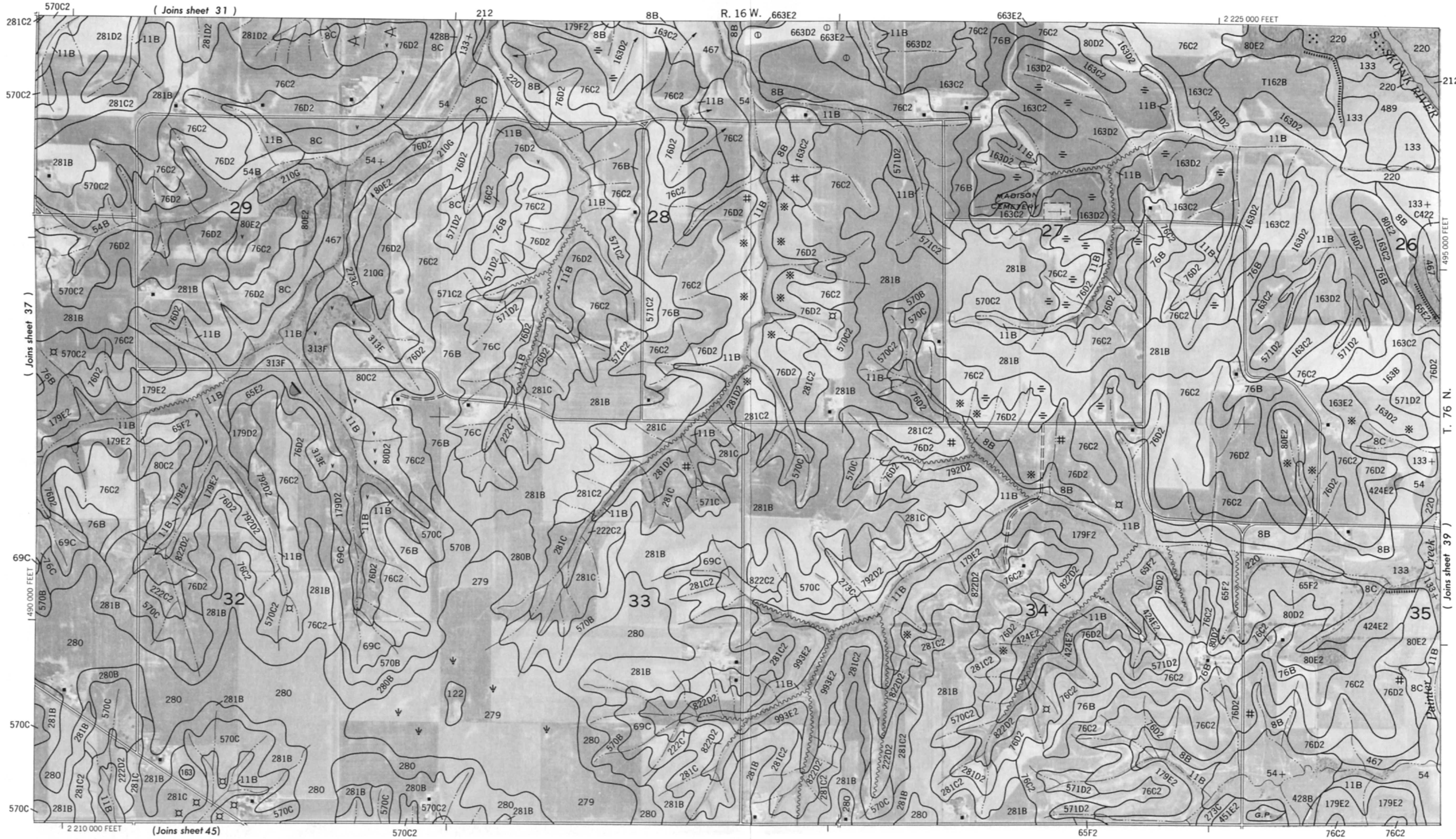

(Joins sheet 28)
2 285 000 FEET
R. 14 W.
T. 76 N.
505 000 FEET
(Joins sheet 34)
(Joins sheet 42)
T75
15
14
13
22
23
24
NORTH
SKUNK
RIVER
Goose Lake
Cedar
Creek
BEDWELL CEMETERY
KEOKUK COUNTY
500 000 FEET
2 300 000 FEET

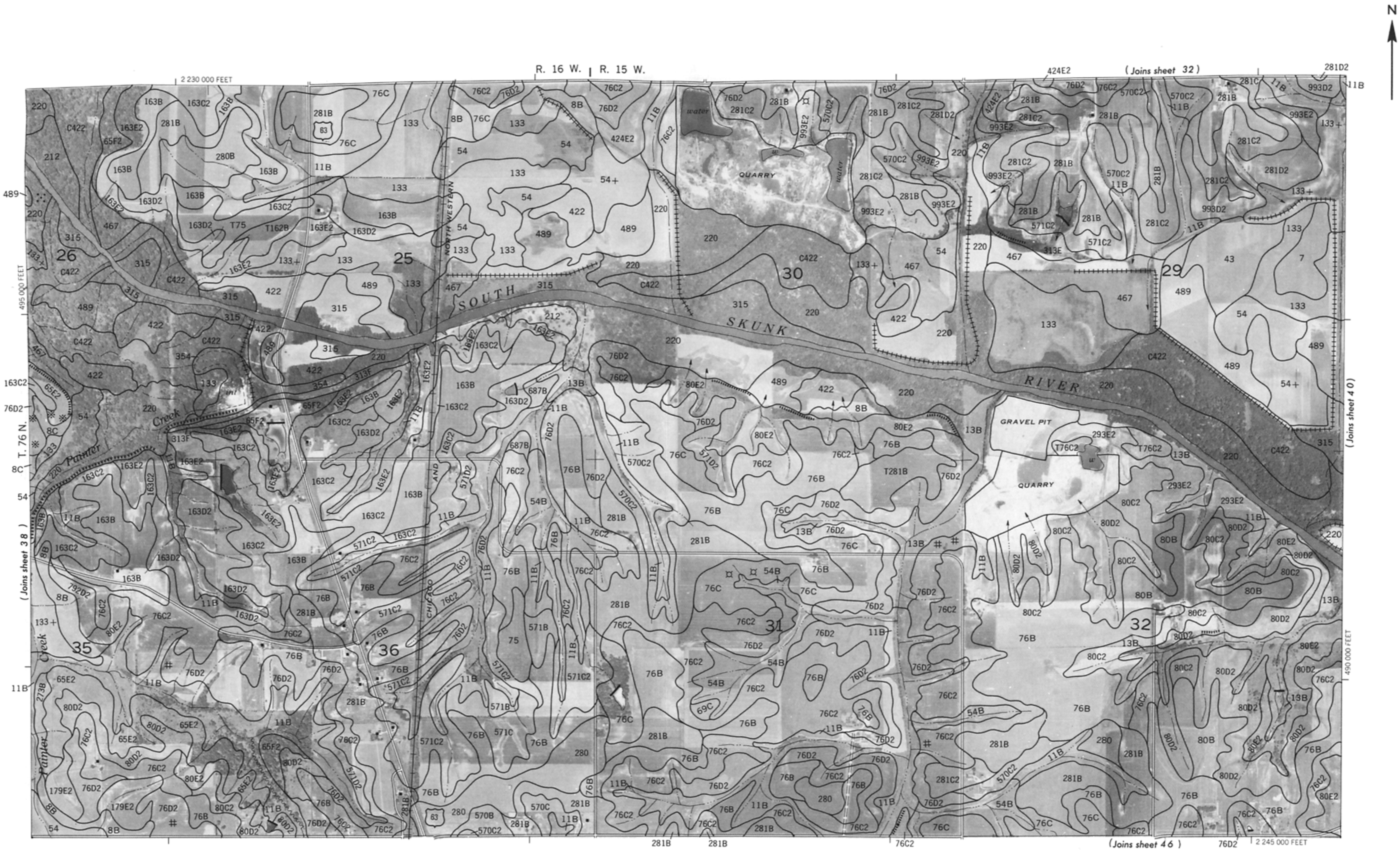
N

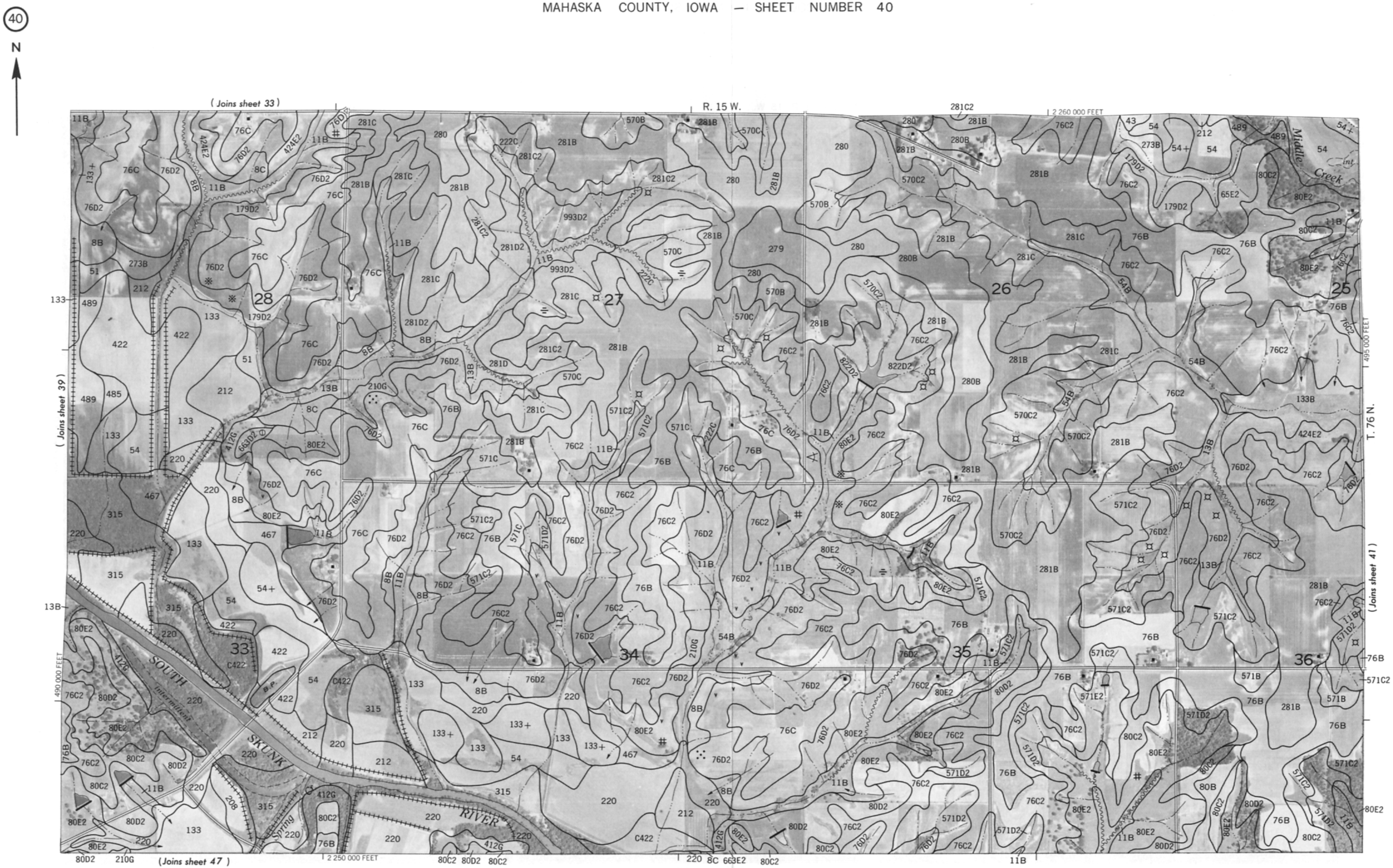

(Joins sheet 29)
R. 17 W.
2 190 000 FEET
495 000 FEET
T. 76 N.
(Joins sheet 37)
(Joins sheet 43)
2 175 000 FEET
490 000 FEET
MARION COUNTY
CHICAGO ROCK ISLAND AND PACIFIC
Muchakinock Creek
27
28
29
30
31
32
33
34


N
R. 17 W. | R. 16 W.
(Joins sheet 30)
(Joins sheet 38)
(Joins sheet 36)
(Joins sheet 44)
T. 76 N.
2 195 000 FEET
2 205 000 FEET
495 000 FEET
490 000 FEET
Leighton
Muchakinock
Creek
CHICAGO
ROCK ISLAND
AND
PACIFIC
27
26
25
30
34
35
36
31

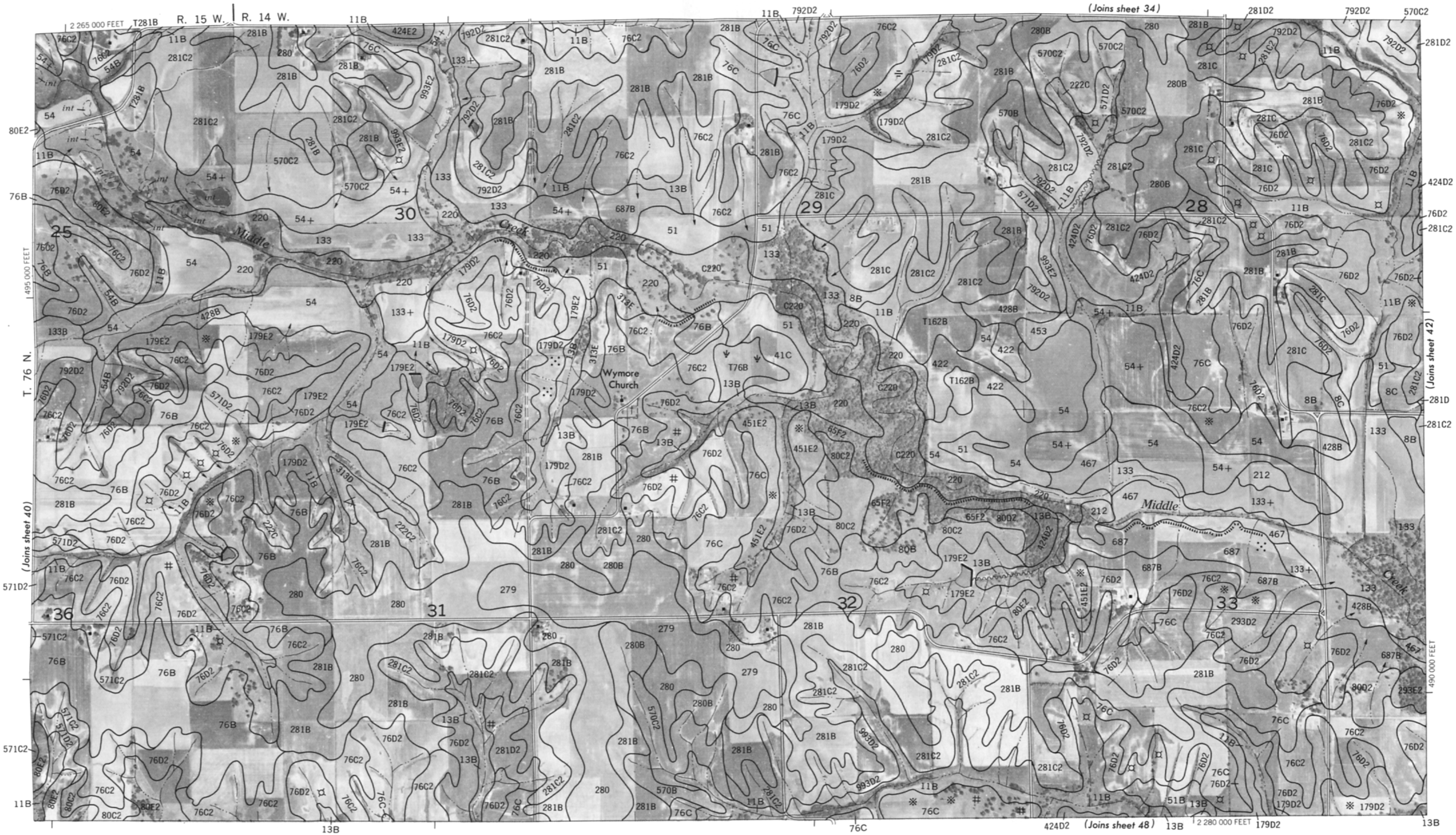
N


(Joins sheet 31)
R. 16 W.
2 225 000 FEET
495 000 FEET
T. 76 N.
(Joins sheet 37)
(Joins sheet 39)
490 000 FEET
2 210 000 FEET
(Joins sheet 45)
S. SKUNK RIVER
MADISON CEMETERY
Painter Creek
29
28
27
26
32
33
34
35
G. P.

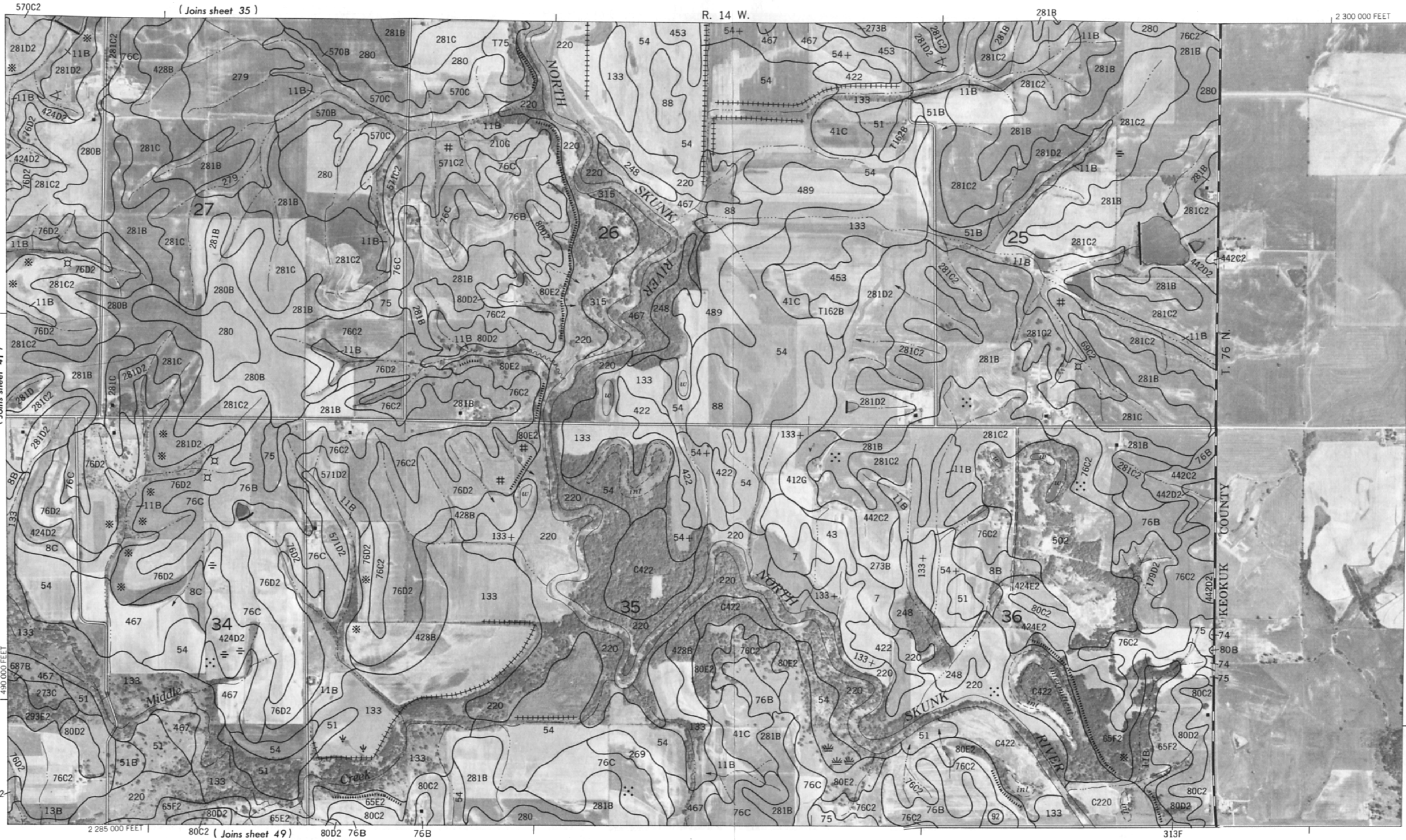

N
R. 16 W.
R. 15 W.
2 230 000 FEET
(Joins sheet 32)
(Joins sheet 38)
(Joins sheet 40)
(Joins sheet 46)
495 000 FEET
490 000 FEET
2 245 000 FEET
T. 76 N.
SOUTH SKUNK RIVER
Painter Creek
NORTH WESTERN
CHICAGO AND
QUARRY
GRAVEL PIT
water
63
25
26
29
30
31
32
35
36

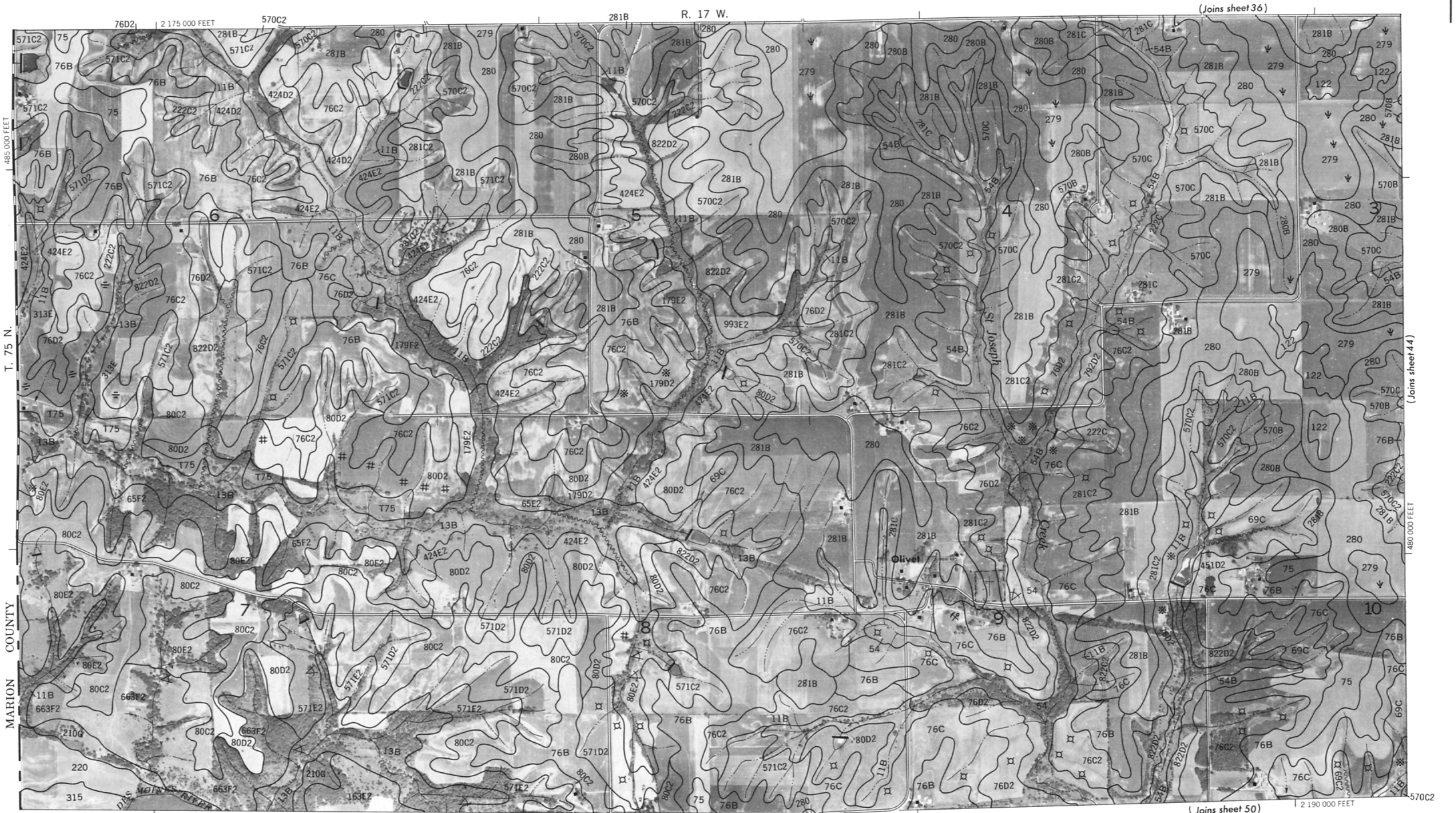

40
N
(Joins sheet 33)
R. 15 W.
2 260 000 FEET
(Joins sheet 39)
(Joins sheet 41)
(Joins sheet 47)
T. 76 N.
495 000 FEET
490 000 FEET
2 250 000 FEET
28
27
26
25
33
34
35
36
Middle
Creek
SOUTH
SKUNK
RIVER
Intermittent
Spring
B.P.

N

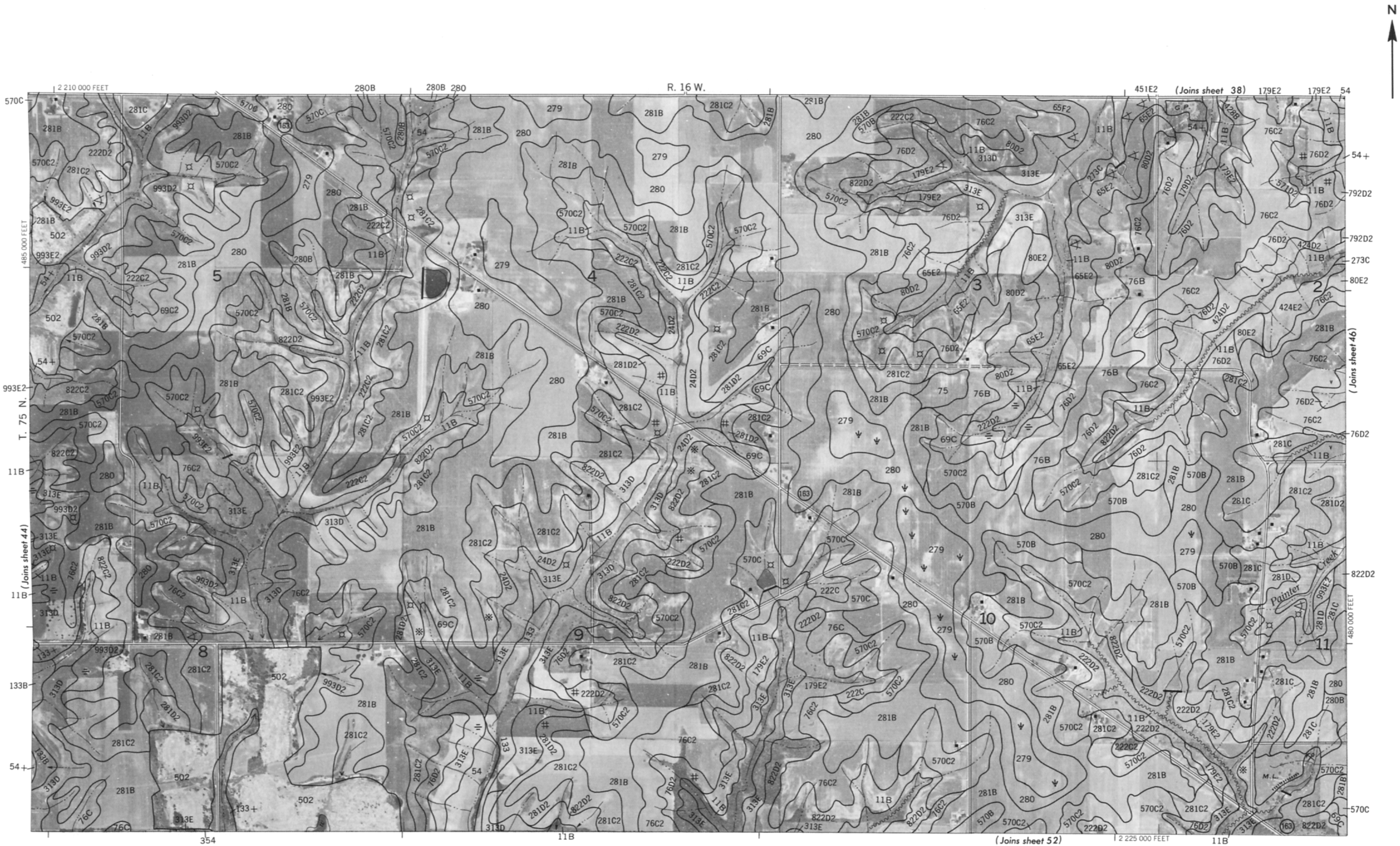

(Joins sheet 34)
(Joins sheet 40)
(Joins sheet 42)
(Joins sheet 48)
R. 15 W.
R. 14 W.
T. 76 N.
2 265 000 FEET
495 000 FEET
490 000 FEET
2 280 000 FEET
Middle
Creek
Wymore Church
25
30
29
28
36
31
32
33

N


(Joins sheet 35)
R. 14 W.
2 300 000 FEET
T. 76 N.
495 000 FEET
(Joins sheet 41)
490 000 FEET
2 285 000 FEET
(Joins sheet 49)
NORTH
SKUNK
RIVER
Middle
Creek
KEOKUK COUNTY
27
26
25
34
35
36
92
313F

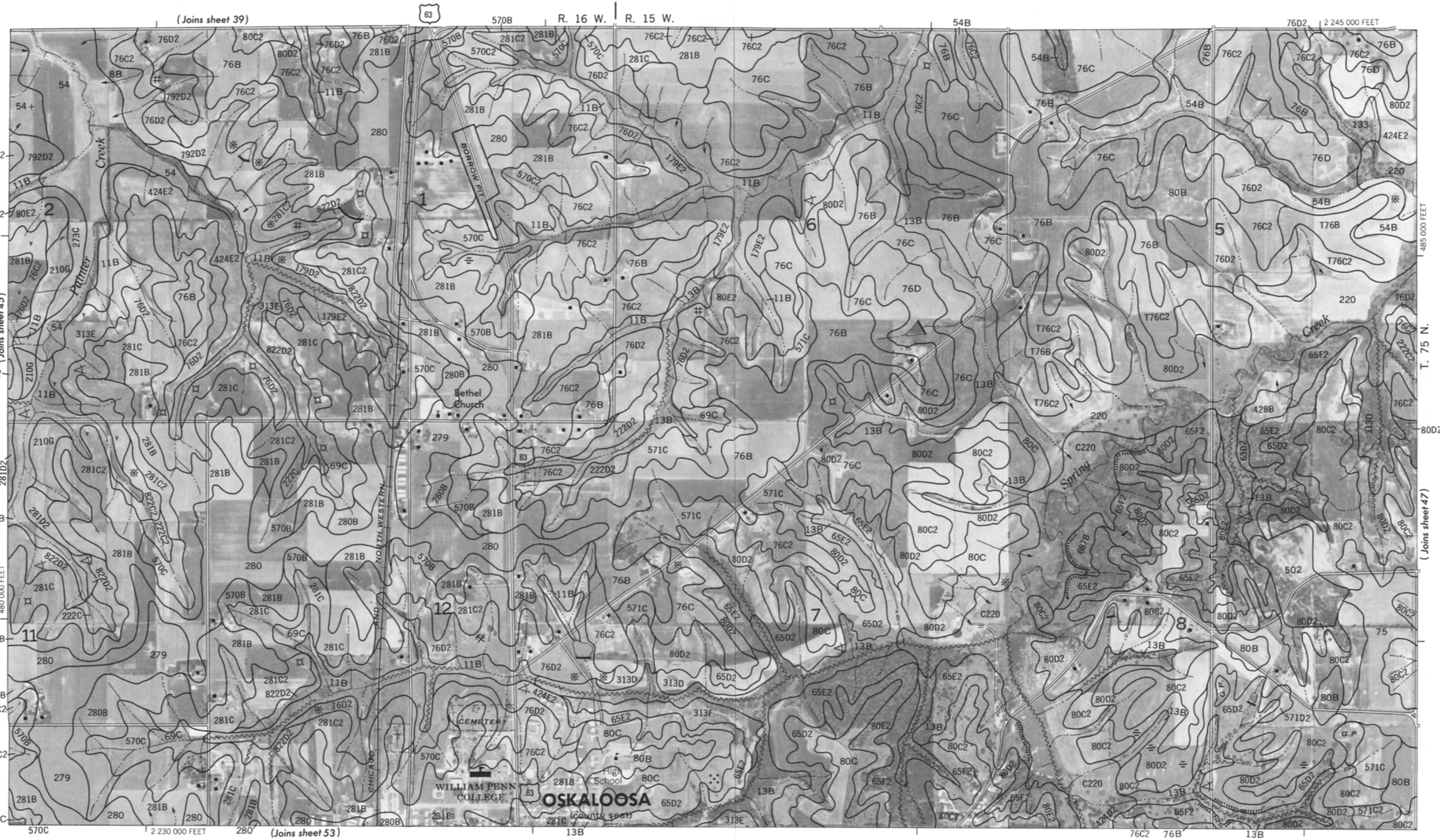

N
R. 17 W.
(Joins sheet 36)
(Joins sheet 44)
(Joins sheet 50)
T. 75 N.
MARION COUNTY
2 175 000 FEET
2 190 000 FEET
485 000 FEET
480 000 FEET
Olivet
St Joseph Creek
Des Moines River


N
(Joins sheet 37)
(Joins sheet 43)
(Joins sheet 45)
(Joins sheet 51)
R. 17 W. | R. 16 W.
T. 75 N.
2 205 000 FEET
2 195 000 FEET
485 000 FEET
480 000 FEET
Muchakinock
Creek
CHICAGO
ROCK ISLAND
AND
PACIFIC
1
2
3
6
7
10
11
12

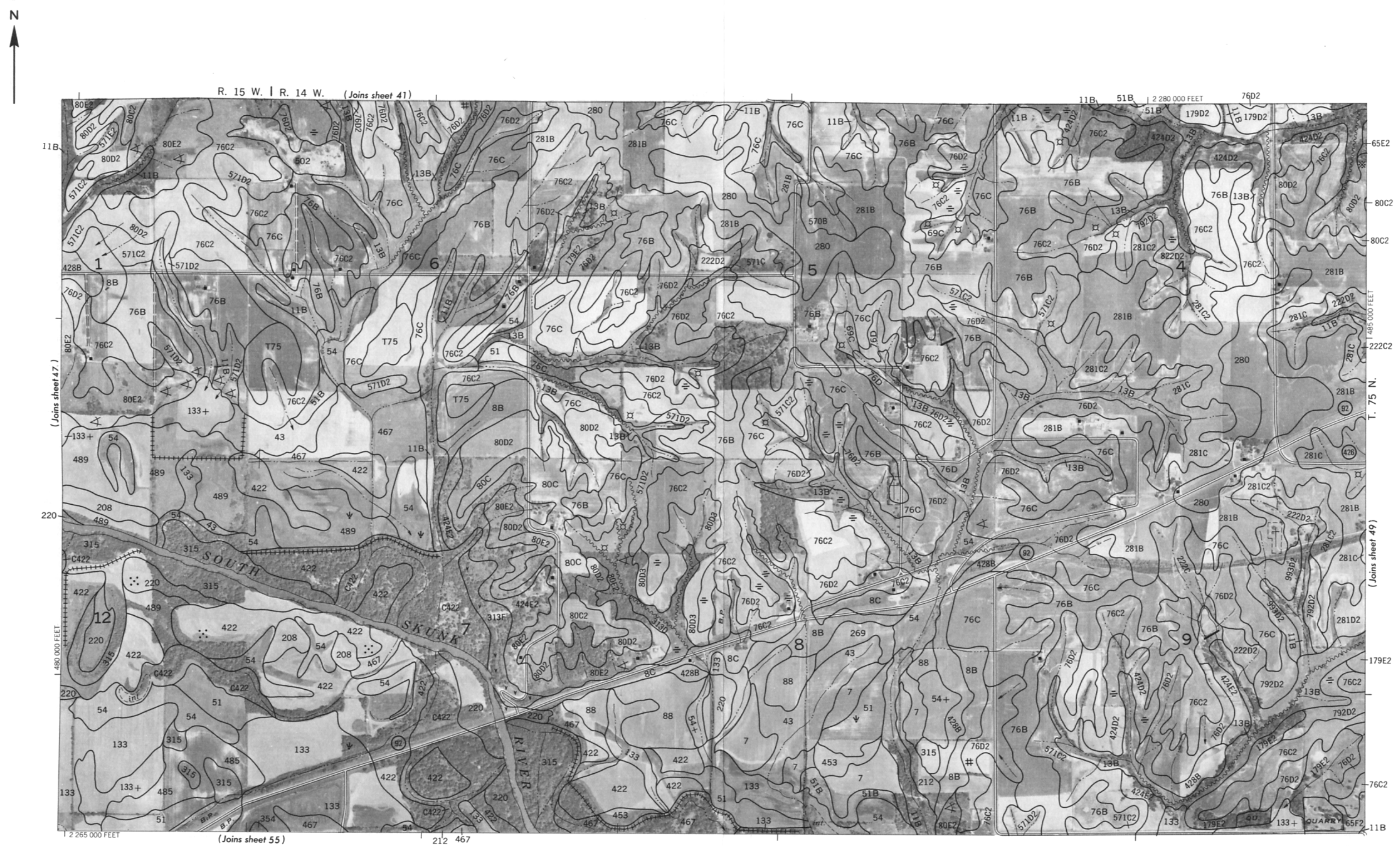

N
2 210 000 FEET
R. 16 W.
(Joins sheet 38)
485 000 FEET
T. 75 N.
(Joins sheet 44)
(Joins sheet 46)
480 000 FEET
(Joins sheet 52)
2 225 000 FEET
Painter Creek

46

N

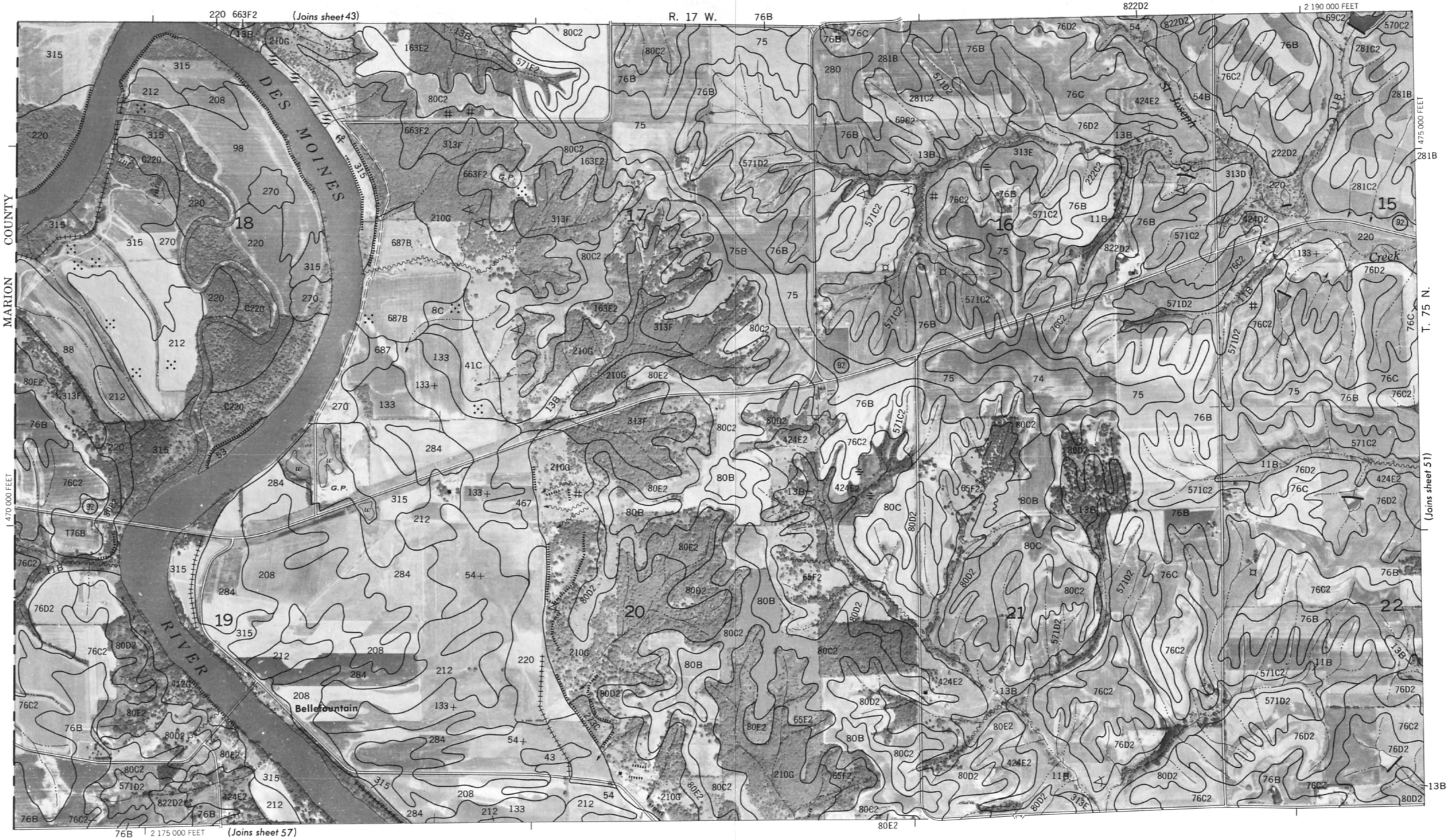

(Joins sheet 39)
R. 16 W.
R. 15 W.
2 245 000 FEET
485 000 FEET
T. 75 N.
(Joins sheet 45)
(Joins sheet 47)
480 000 FEET
2 230 000 FEET
(Joins sheet 53)
BORROW PIT
Bethel Church
Palmer Creek
Spring Creek
NORTH WESTERN
CHICAGO AND
CEMETERY
WILLIAM PENN COLLEGE
High School
OSKALOOSA
(County seat)

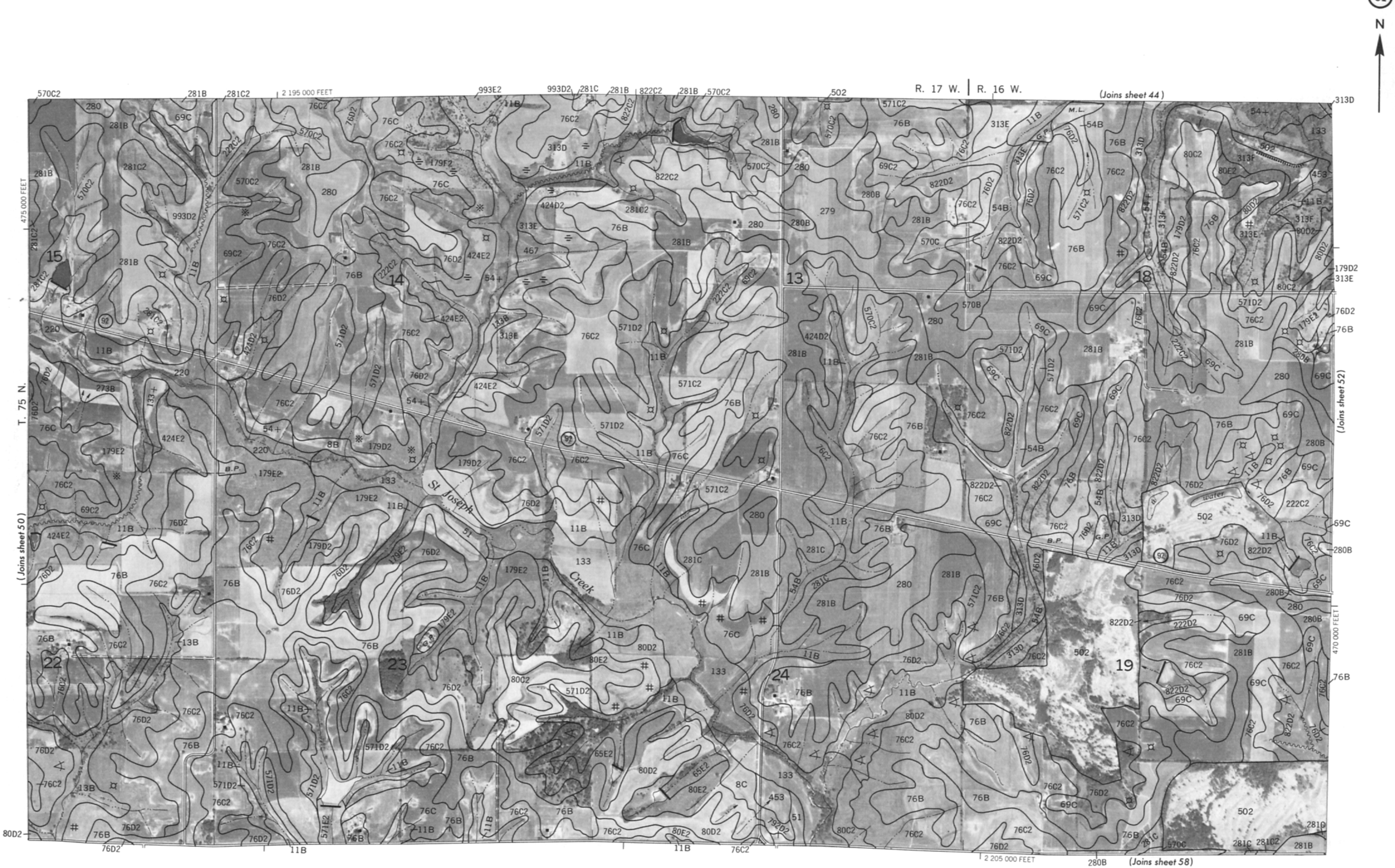

N
R. 15 W.
T. 75 N.
2 250 000 FEET
2 260 000 FEET
485 000 FEET
480 000 FEET
(Joins sheet 40)
(Joins sheet 46)
(Joins sheet 48)
(Joins sheet 54)
SOUTH SKUNK RIVER
Spring Creek
QUAKER CEMETERY
QUARRY
water


N
R. 15 W. | R. 14 W.
(Joins sheet 41)
(Joins sheet 47)
(Joins sheet 49)
(Joins sheet 55)
T. 75 N.
2 280 000 FEET
2 265 000 FEET
485 000 FEET
480 000 FEET
SOUTH
SKUNK
RIVER
QUARRY
92
426
1
4
5
6
7
8
9
12


N
(Joins sheet 42)
R. 14 W.
2 285 000 FEET
T. 75 N.
485 000 FEET
Rose Hill
North White Oak School
NORTH SKUNK RIVER
KEOKUK COUNTY
(Joins sheet 48)
(Joins sheet 56)
2 300 000 FEET
480 000 FEET
1
2
3
10
11
12

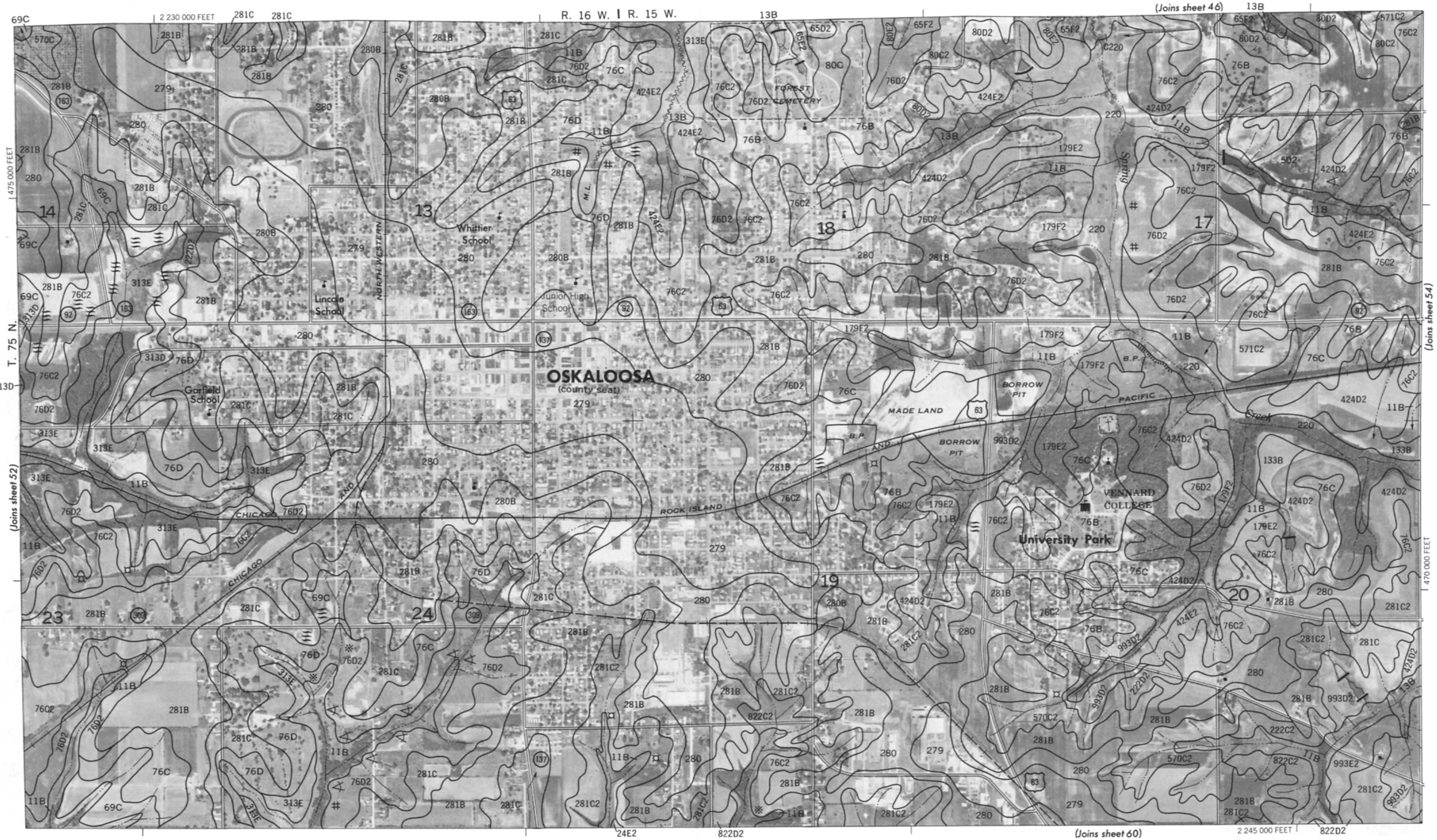
N


(Joins sheet 43)
R. 17 W.
2 190 000 FEET
475 000 FEET
T. 75 N.
(Joins sheet 51)
470 000 FEET
MARION COUNTY
DES MOINES
RIVER
Bellefountain
St Joseph
Creek
G.P.
15
16
17
18
19
20
21
22
2 175 000 FEET
(Joins sheet 57)


51
N
R. 17 W.
R. 16 W.
(Joins sheet 44)
(Joins sheet 52)
(Joins sheet 58)
(Joins sheet 50)
T. 75 N.
2 195 000 FEET
2 205 000 FEET
475 000 FEET
470 000 FEET
St Joseph Creek

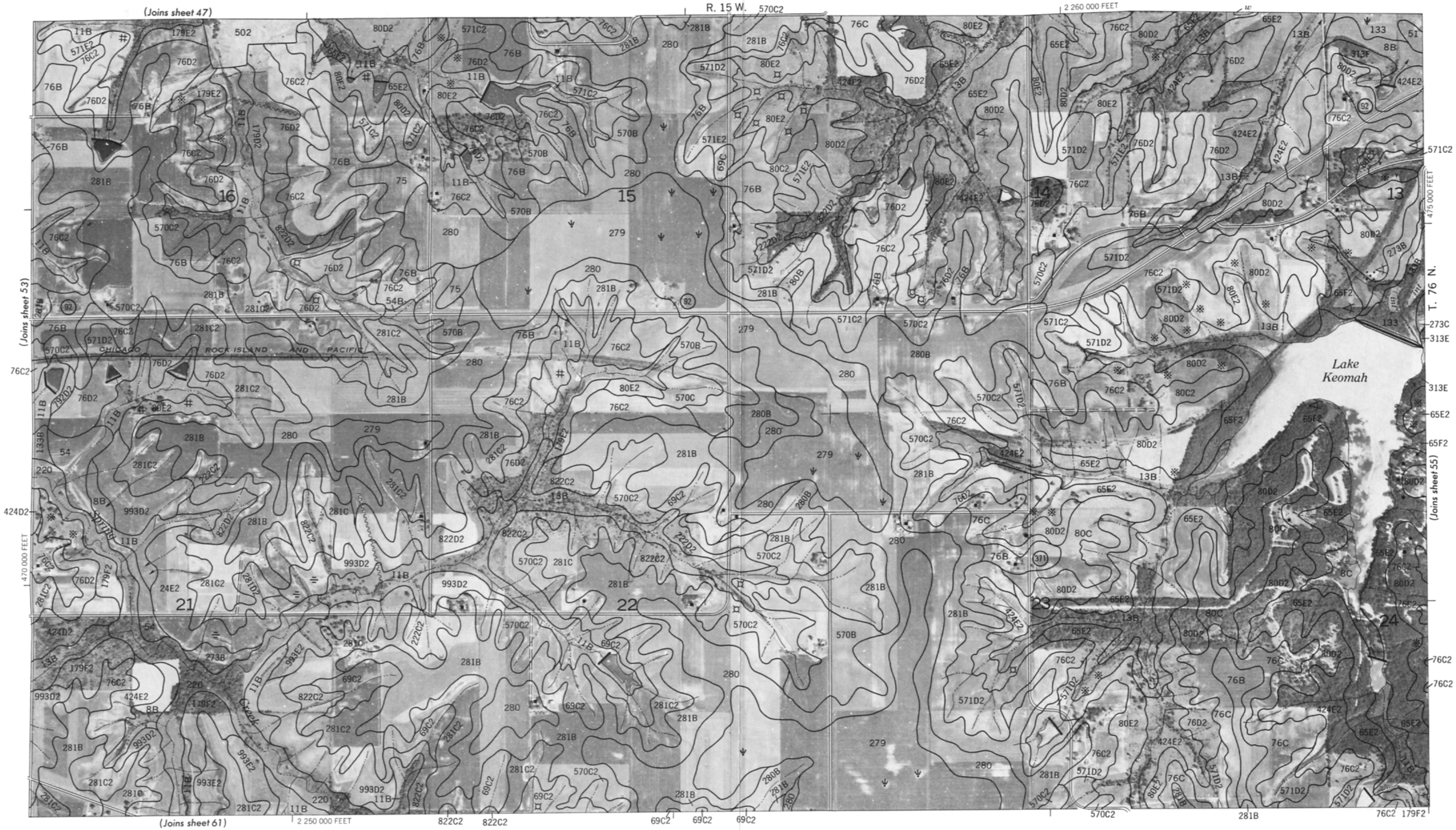

N
(Joins sheet 45)
R. 16 W.
2 225 000 FEET
475 000 FEET
T. 75 N.
(Joins sheet 51)
(Joins sheet 53)
470 000 FEET
2 210 000 FEET
(Joins sheet 59)
Evans
Beacon
Muchakinock
Creek
CHICAGO ROCK ISLAND AND PACIFIC
CHICAGO AND NORTH WESTERN
MADE LAND
G.P.
14
15
16
17
20
21
22
23

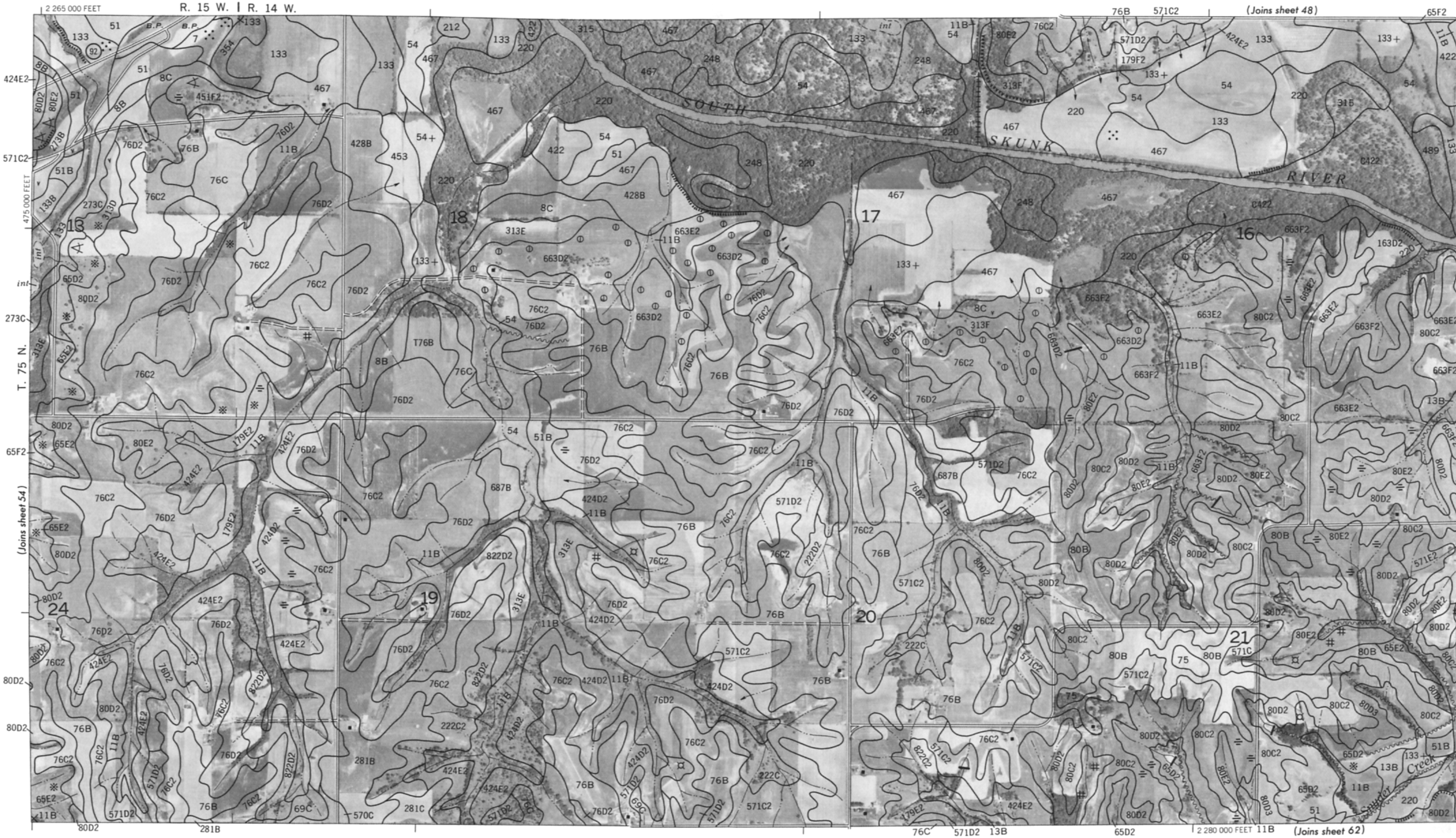
N



2 230 000 FEET
R. 16 W. | R. 15 W.
(Joins sheet 46)
475 000 FEET
T. 75 N.
(Joins sheet 52)
(Joins sheet 54)
470 000 FEET
2 245 000 FEET
(Joins sheet 60)
OSKALOOSA
(county seat)
FOREST CEMETERY
Whittier School
Lincoln School
Junior High School
Garfield School
NORTH WESTERN
MADE LAND
BORROW PIT
B.P.
PACIFIC
AND
ROCK ISLAND
CHICAGO
Spring Creek
VENNARD COLLEGE
University Park

N


(Joins sheet 47)
R. 15 W.
2 260 000 FEET
T. 76 N.
475 000 FEET
(Joins sheet 55)
Lake Keomah
(Joins sheet 53)
470 000 FEET
CHICAGO ROCK ISLAND AND PACIFIC
16
15
14
13
21
22
23
24
(Joins sheet 61)
2 250 000 FEET


2 265 000 FEET
R. 15 W.
R. 14 W.
(Joins sheet 48)
(Joins sheet 54)
(Joins sheet 56)
(Joins sheet 62)
T. 75 N.
475 000 FEET
470 000 FEET
2 280 000 FEET
SOUTH
SKUNK
RIVER
Creek
13
16
17
18
19
20
21
24

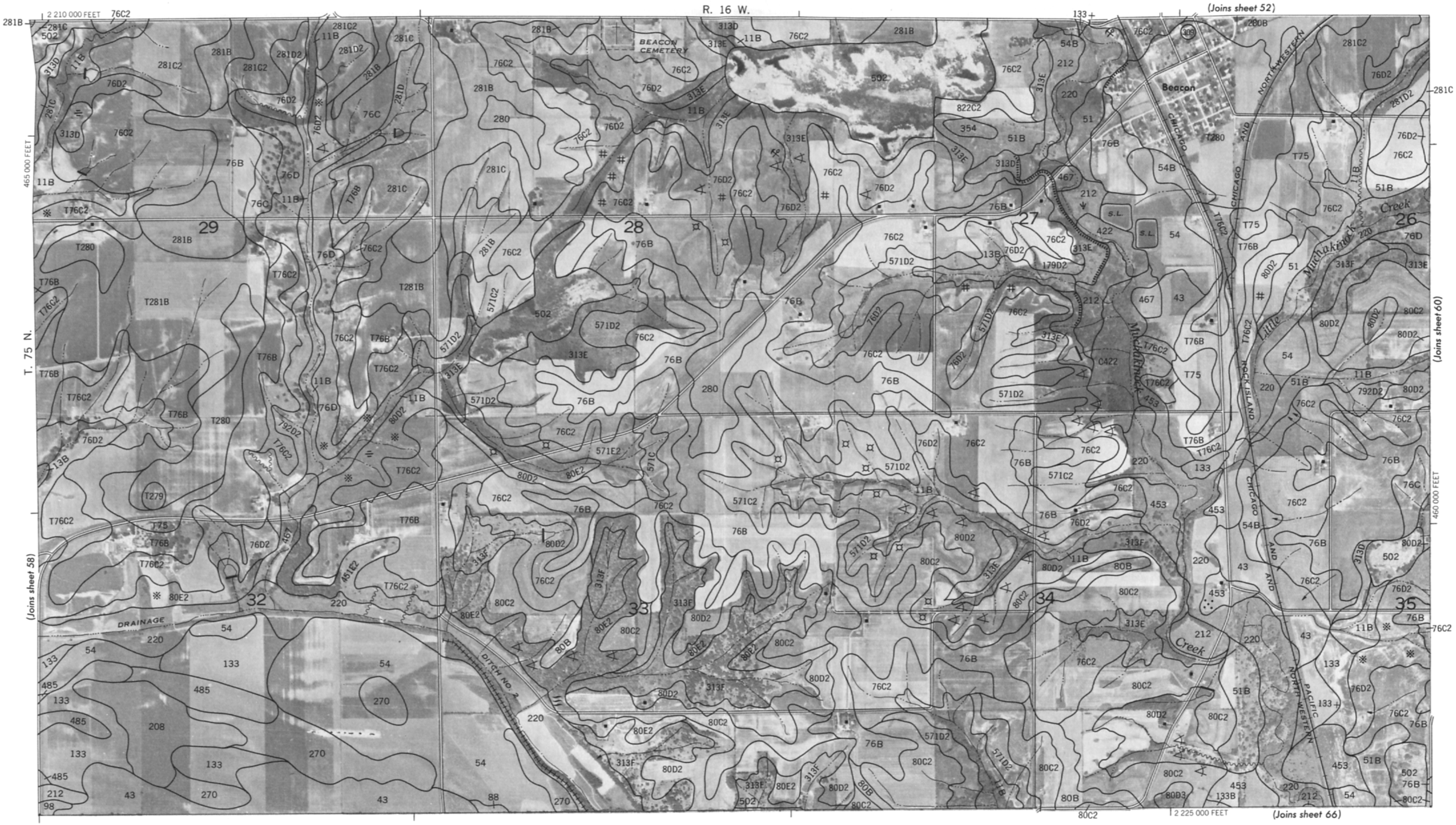

N
(Joins sheet 49)
R. 14 W.
2 300 000 FEET
475 000 FEET
T. 75 N.
KEOKUK COUNTY
(Joins sheet 55)
470 000 FEET
2 285 000 FEET
(Joins sheet 63)
SOUTH SKUNK RIVER
Creek
Snyder
TIOGA CEMETERY
15
14
13
22
23
24


N
R. 17 W.
T. 75 N.
MARION COUNTY
(Joins sheet 50)
(Joins sheet 58)
(Joins sheet 64)
2 175 000 FEET
2 190 000 FEET
465 000 FEET
460 000 FEET
DES MOINES RIVER
CEDAR CREEK
GRAVEL PIT
water
intermittent
G.P.
27
28
29
30
31
32
33
34

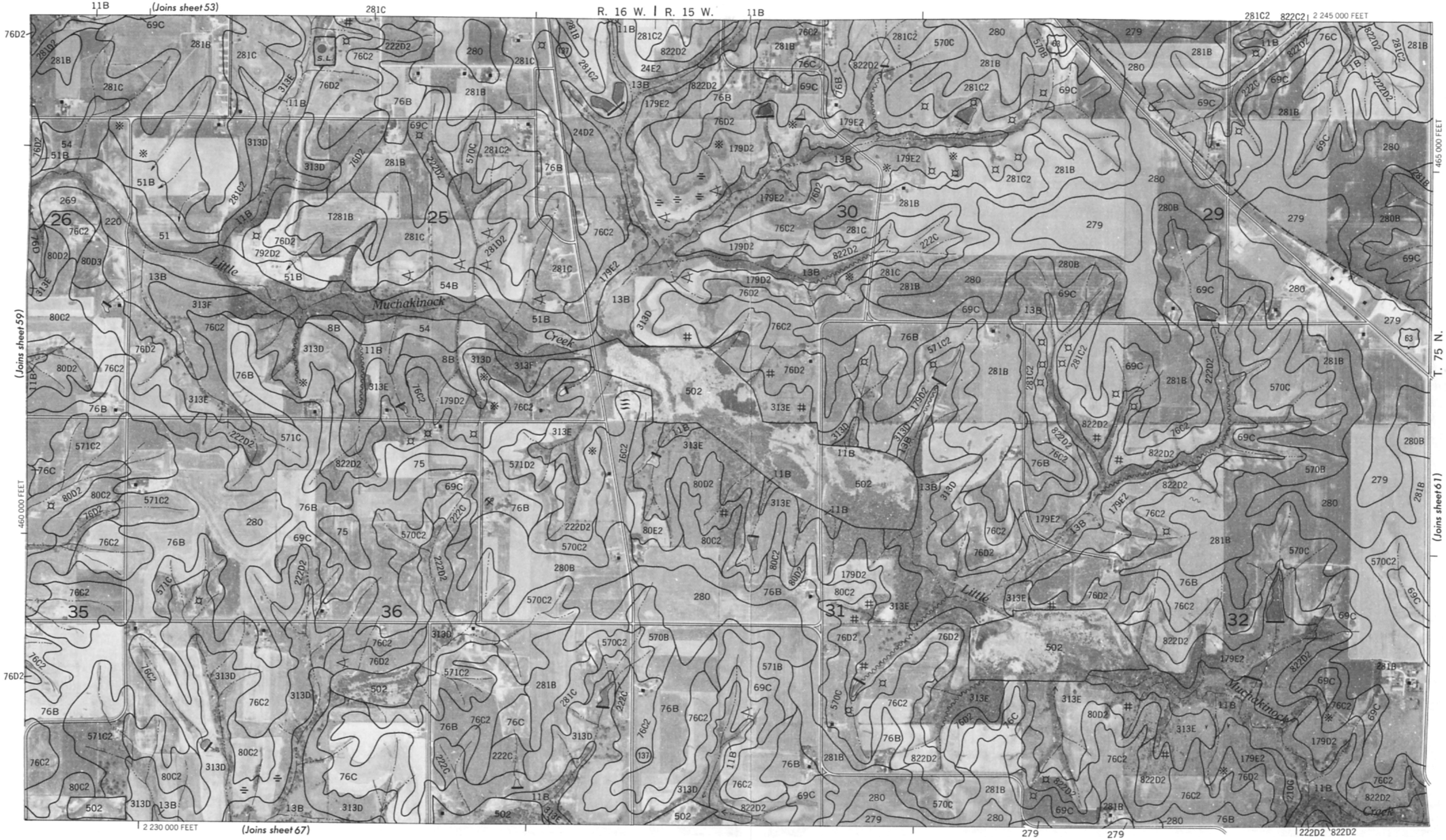
N


(Joins sheet 51)
R. 17 W.
R. 16 W.
2 205 000 FEET
465 000 FEET
(Joins sheet 57)
460 000 FEET
(Joins sheet 59)
T. 75 N.
(Joins sheet 65)
2 195 000 FEET
DES MOINES RIVER
Fosterdale
St. Joseph Creek
water
27
26
25
30
34
35
36
31

N


R. 16 W.
T. 75 N.
(Joins sheet 52)
(Joins sheet 60)
(Joins sheet 66)
(Joins sheet 58)
2 210 000 FEET
465 000 FEET
460 000 FEET
2 225 000 FEET
BEACON CEMETERY
Beacon
309
CHICAGO AND NORTH WESTERN
CHICAGO ROCK ISLAND AND PACIFIC
Little Muchakinock Creek
Muchakinock Creek
DRAINAGE DITCH NO. 2
S.L.
26
27
28
29
32
33
34
35

N


(Joins sheet 53)
R. 16 W.
R. 15 W.
2 245 000 FEET
465 000 FEET
T. 75 N.
(Joins sheet 59)
(Joins sheet 61)
460 000 FEET
2 230 000 FEET
(Joins sheet 67)
Little Muchakinock Creek
25
26
29
30
31
32
35
36
63
137

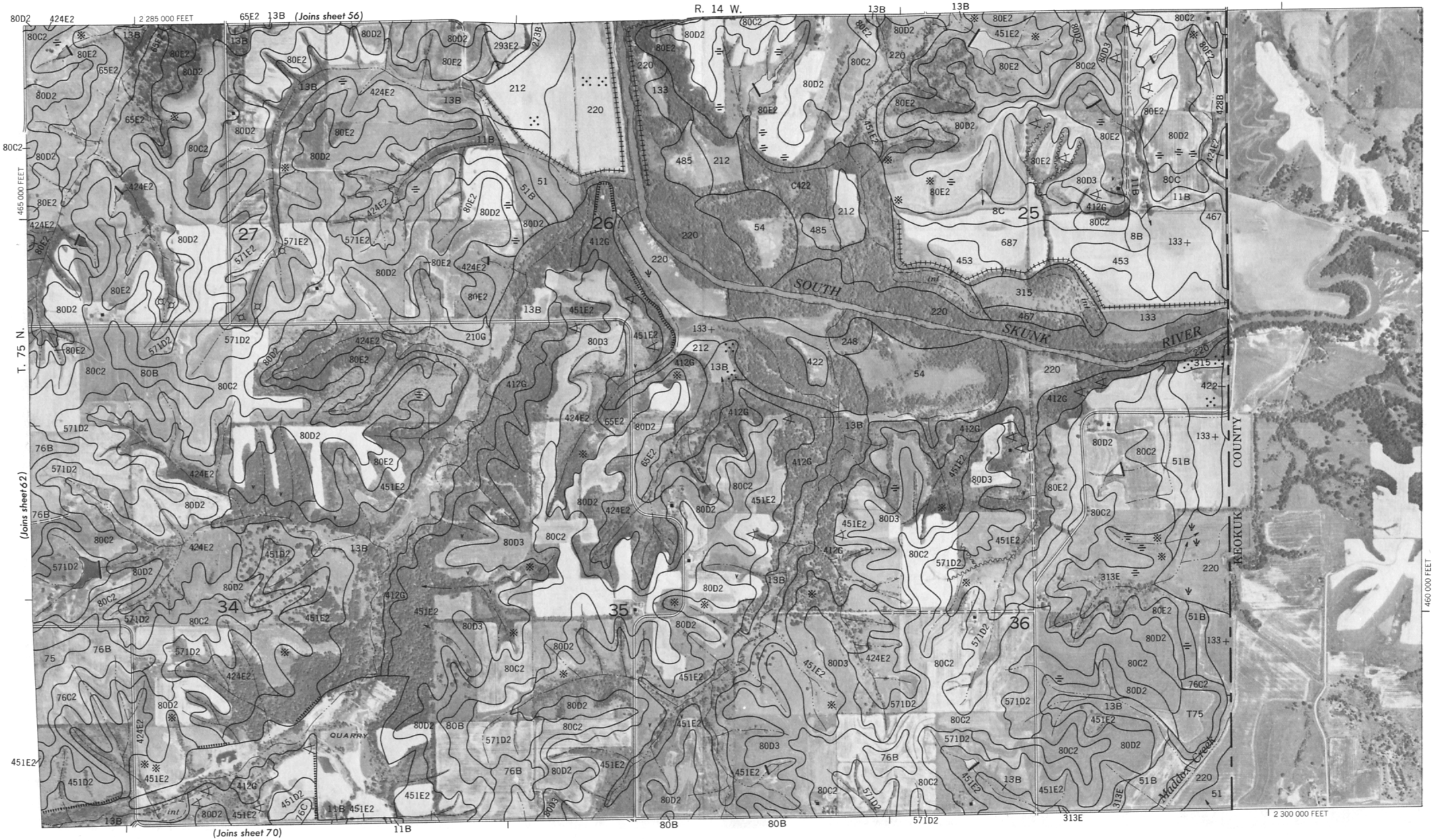
N


(Joins sheet 54)
R. 15 W.
2 250 000 FEET
465 000 FEET
T. 75 N.
(Joins sheet 60)
(Joins sheet 62)
460 000 FEET
(Joins sheet 68)
2 265 000 FEET
Spring
Creek
BLOOMFIELD CEMETERY
63
27
26
25
28
33
34
35
36

N

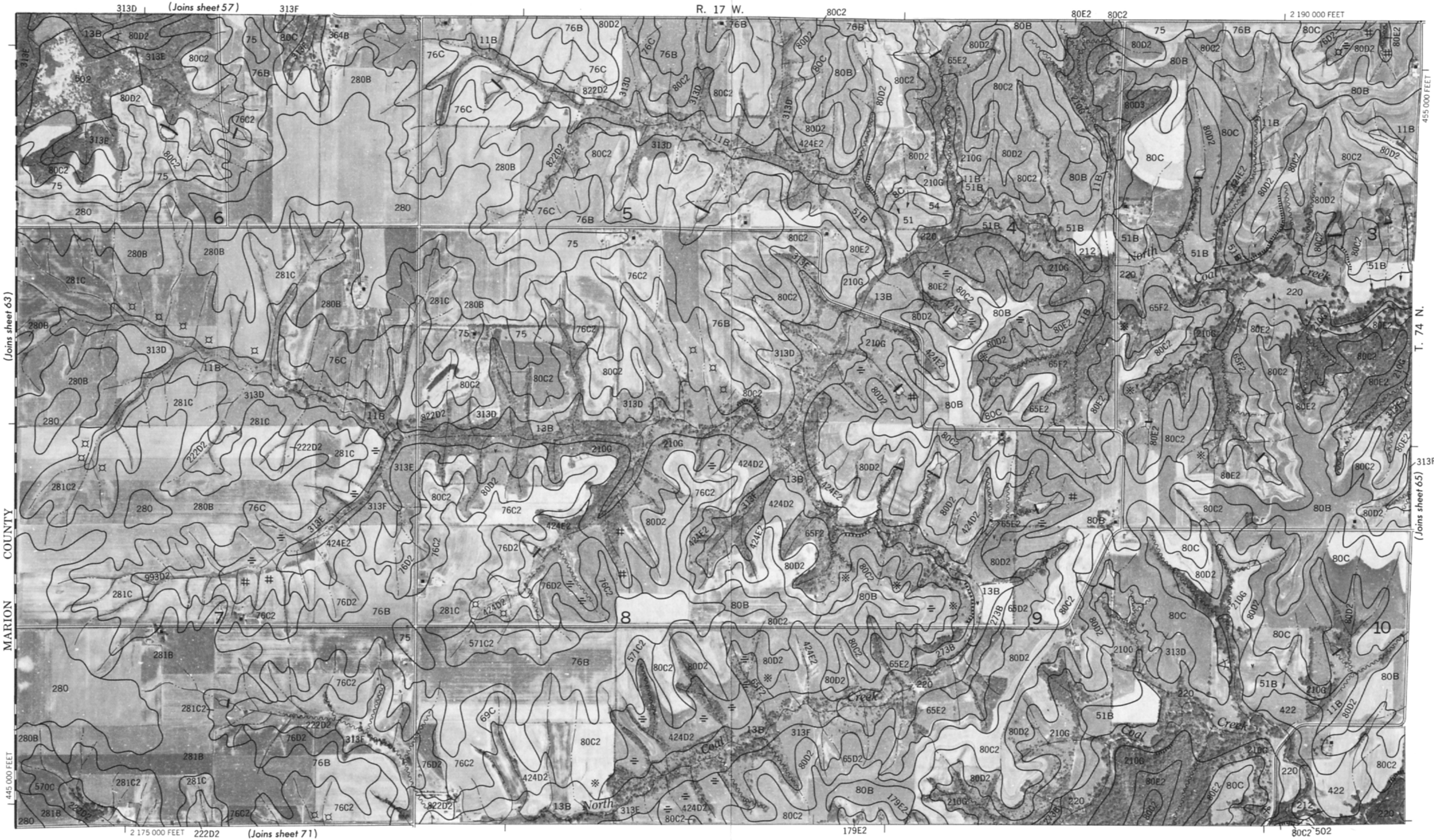
R. 15 W.
R. 14 W.
(Joins sheet 55)
(Joins sheet 61)
(Joins sheet 63)
(Joins sheet 69)
T. 75 N.
2 280 000 FEET
2 270 000 FEET
465 000 FEET
460 000 FEET
White Oak Grove Church
Snyder Creek
Wright
25
30
29
28
36
31
32
33

N


(Joins sheet 56)
R. 14 W.
2 285 000 FEET
465 000 FEET
T. 75 N.
(Joins sheet 62)
27
26
25
34
35
36
SOUTH
SKUNK
RIVER
QUARRY
Maddox Creek
KEOKUK
COUNTY
460 000 FEET
2 300 000 FEET
(Joins sheet 70)

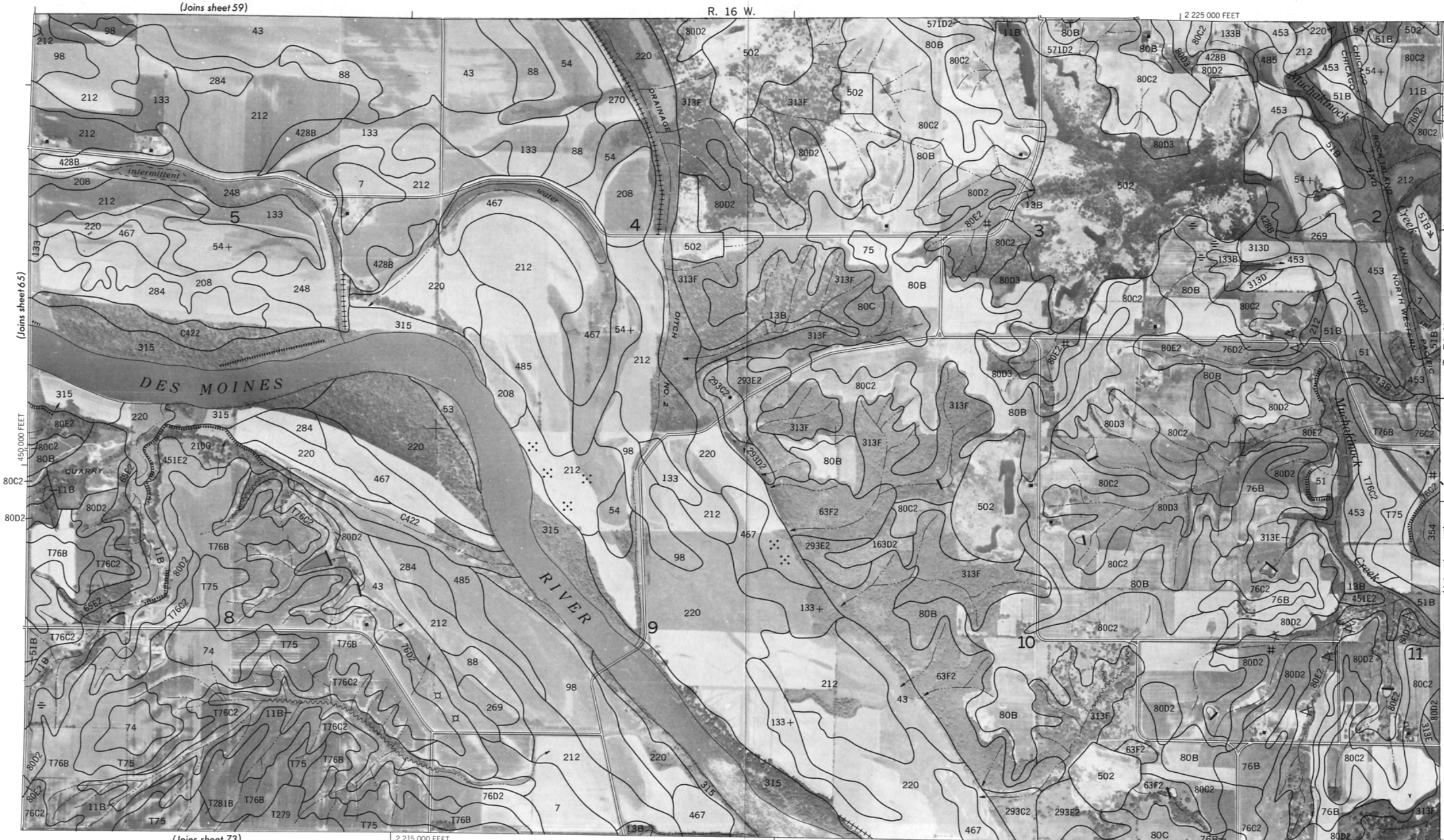
N

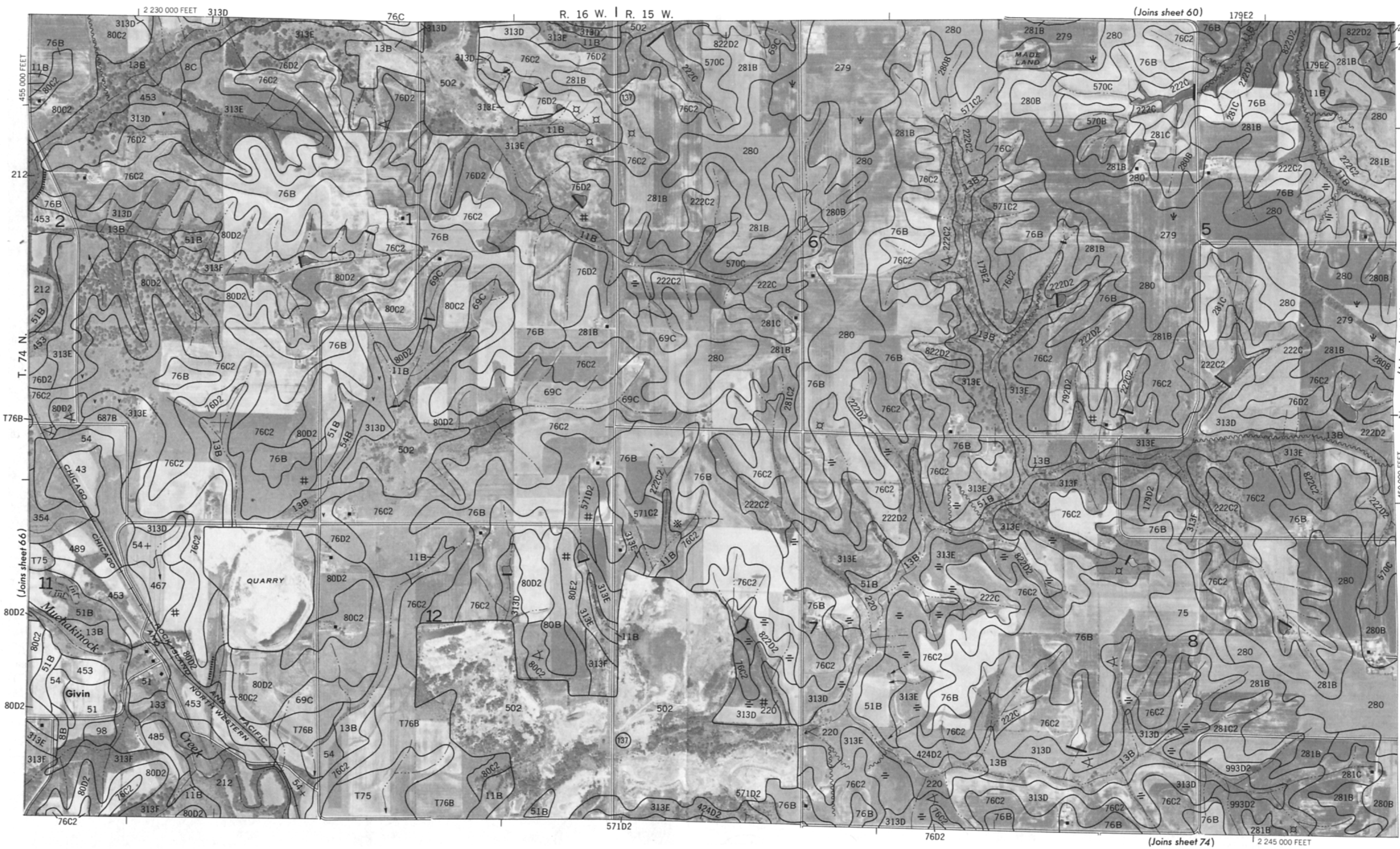
MAHASKA COUNTY, IOWA — SHEET NUMBER 64



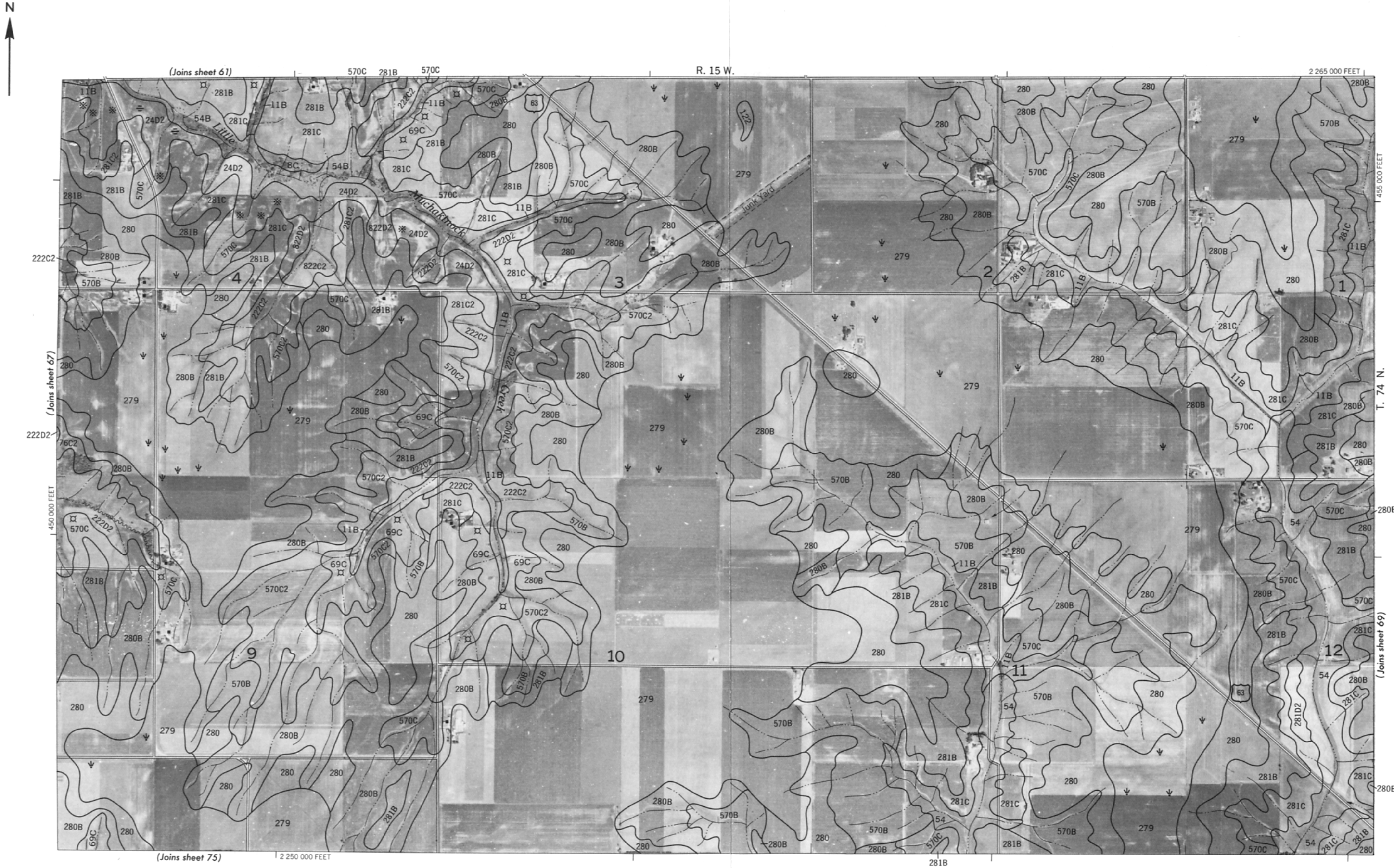

N
R. 17 W.
R. 16 W.
(Joins sheet 58)
(Joins sheet 66)
(Joins sheet 72)
(Joins sheet 64)
T. 74 N.
2 195 000 FEET
2 210 000 FEET
455 000 FEET
450 000 FEET
DES MOINES
RIVER
St. Joseph
Creek
North
Coal
Creek
QUARRY
1
2
3
6
7
10
11
12

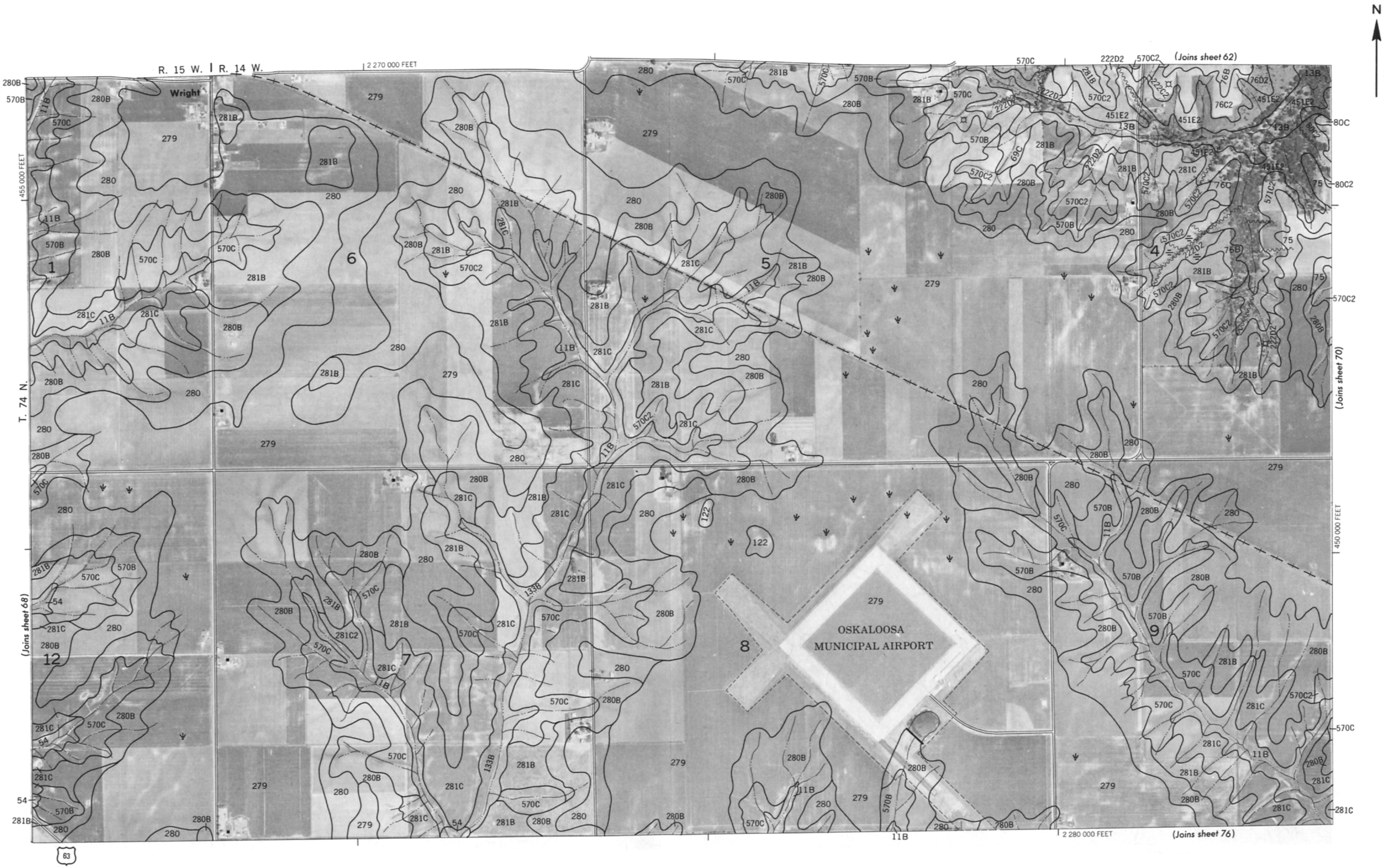
N


(Joins sheet 59)
R. 16 W.
2 225 000 FEET
455 000 FEET
(Joins sheet 65)
450 000 FEET
T. 74 N.
(Joins sheet 67)
(Joins sheet 73)
2 215 000 FEET
DES MOINES
RIVER
DRAINAGE
DITCH
NO. 2
Intermittent
water
QUARRY
Muchakinock
Creek
CHICAGO
ROCK ISLAND
AND
PACIFIC
CHICAGO
AND
NORTH WESTERN
5
4
3
2
8
9
10
11


N
2 230 000 FEET
R. 16 W. | R. 15 W.
(Joins sheet 60)
455 000 FEET
T. 74 N.
(Joins sheet 66)
(Joins sheet 68)
450 000 FEET
(Joins sheet 74)
2 245 000 FEET
MADE LAND
QUARRY
CHICAGO
ROCK ISLAND AND PACIFIC
CHICAGO AND NORTH WESTERN
Muchakinock Creek
Givin
137
1
2
5
6
7
8
11
12

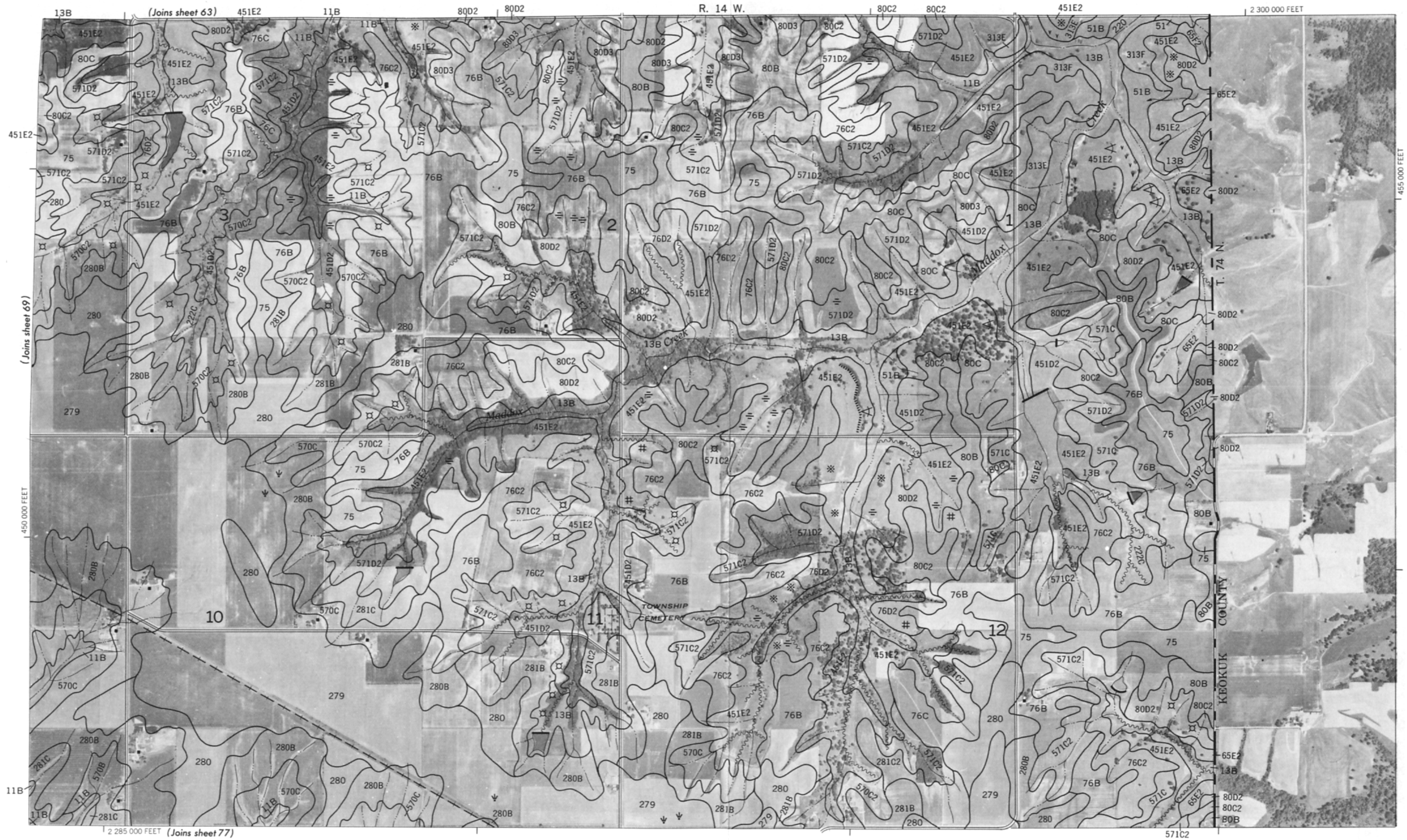
MAHASKA COUNTY, IOWA — SHEET NUMBER 68



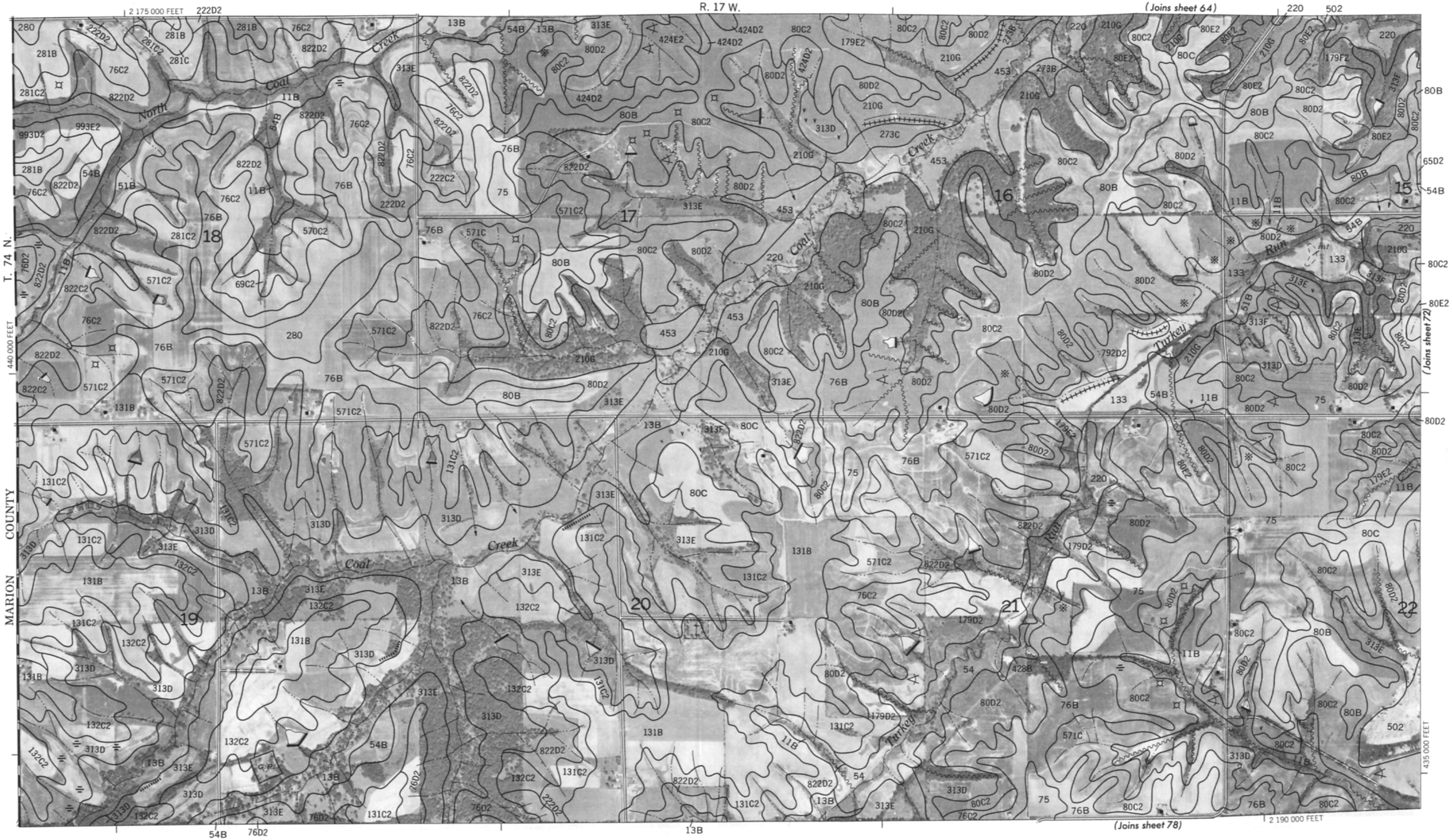

N
R. 15 W.
R. 14 W.
2 270 000 FEET
2 280 000 FEET
455 000 FEET
450 000 FEET
T. 74 N.
(Joins sheet 62)
(Joins sheet 70)
(Joins sheet 76)
(Joins sheet 68)
Wright
OSKALOOSA
MUNICIPAL AIRPORT
1
4
5
6
7
8
9
12
63

N

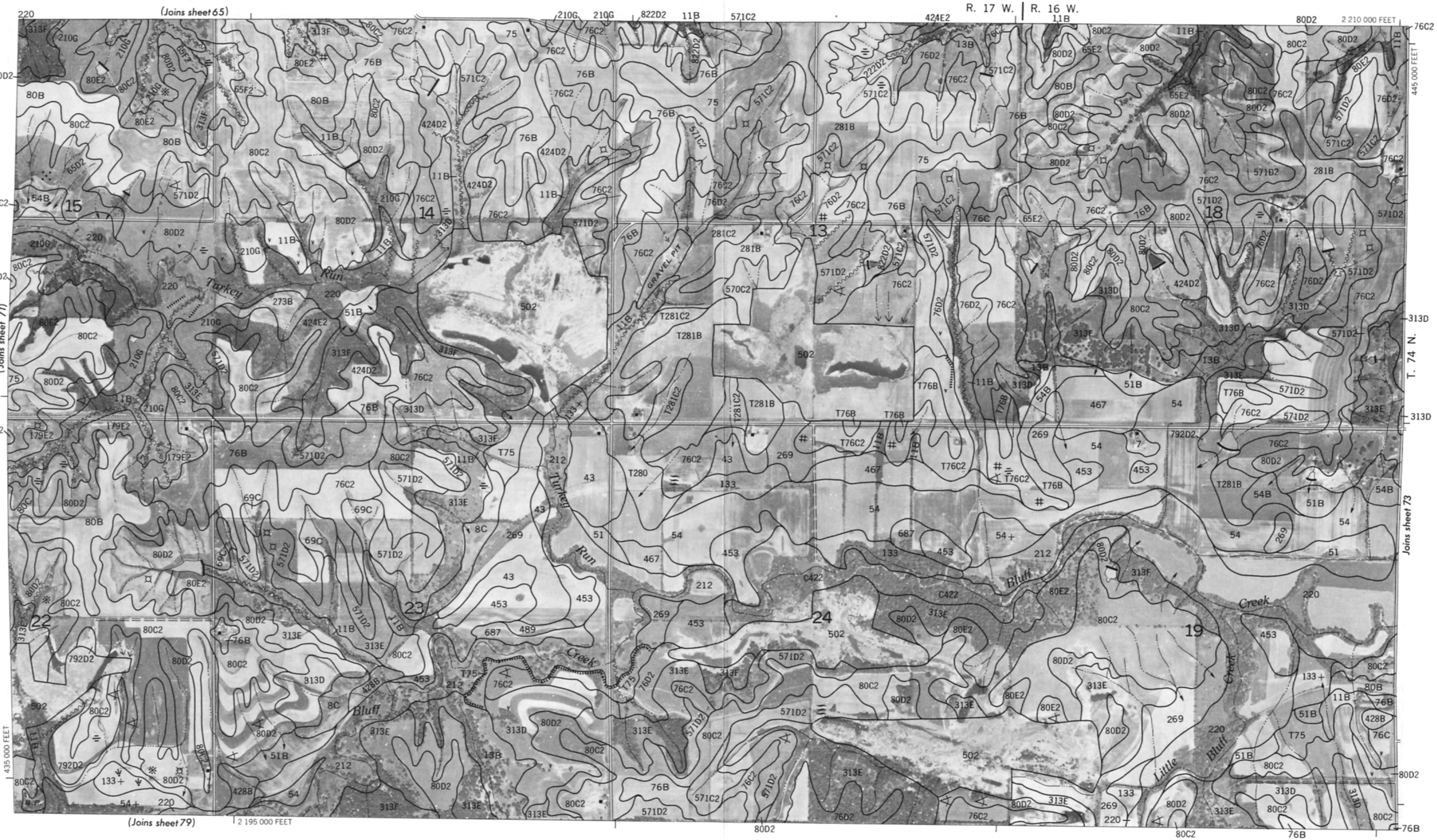
MAHASKA COUNTY, IOWA — SHEET NUMBER 70



N


(Joins sheet 64)
R. 17 W.
2 175 000 FEET
T. 74 N.
440 000 FEET
MARION COUNTY
(Joins sheet 72)
435 000 FEET
(Joins sheet 78)
2 190 000 FEET
North Coal Creek
Coal Creek
Turkey Run
15
16
17
18
19
20
21
22
G.P.

N

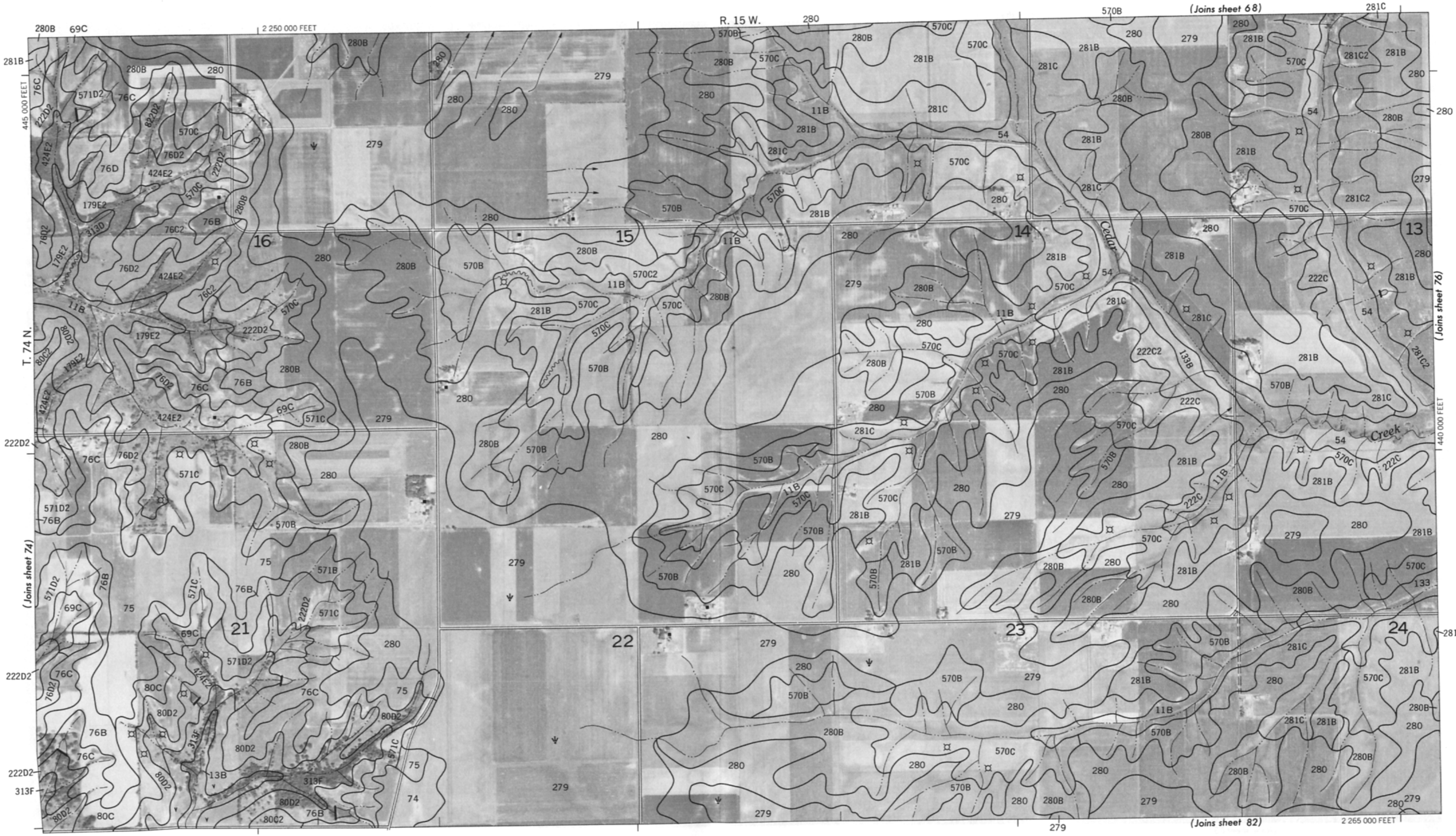

(Joins sheet 65)
R. 17 W.
R. 16 W.
2 210 000 FEET
445 000 FEET
(Joins sheet 71)
T. 74 N.
Joins sheet 73
435 000 FEET
(Joins sheet 79)
2 195 000 FEET
15
14
13
18
22
23
24
19
Turkey Run
GRAVEL PIT
Bluff Creek
Little Bluff Creek

N

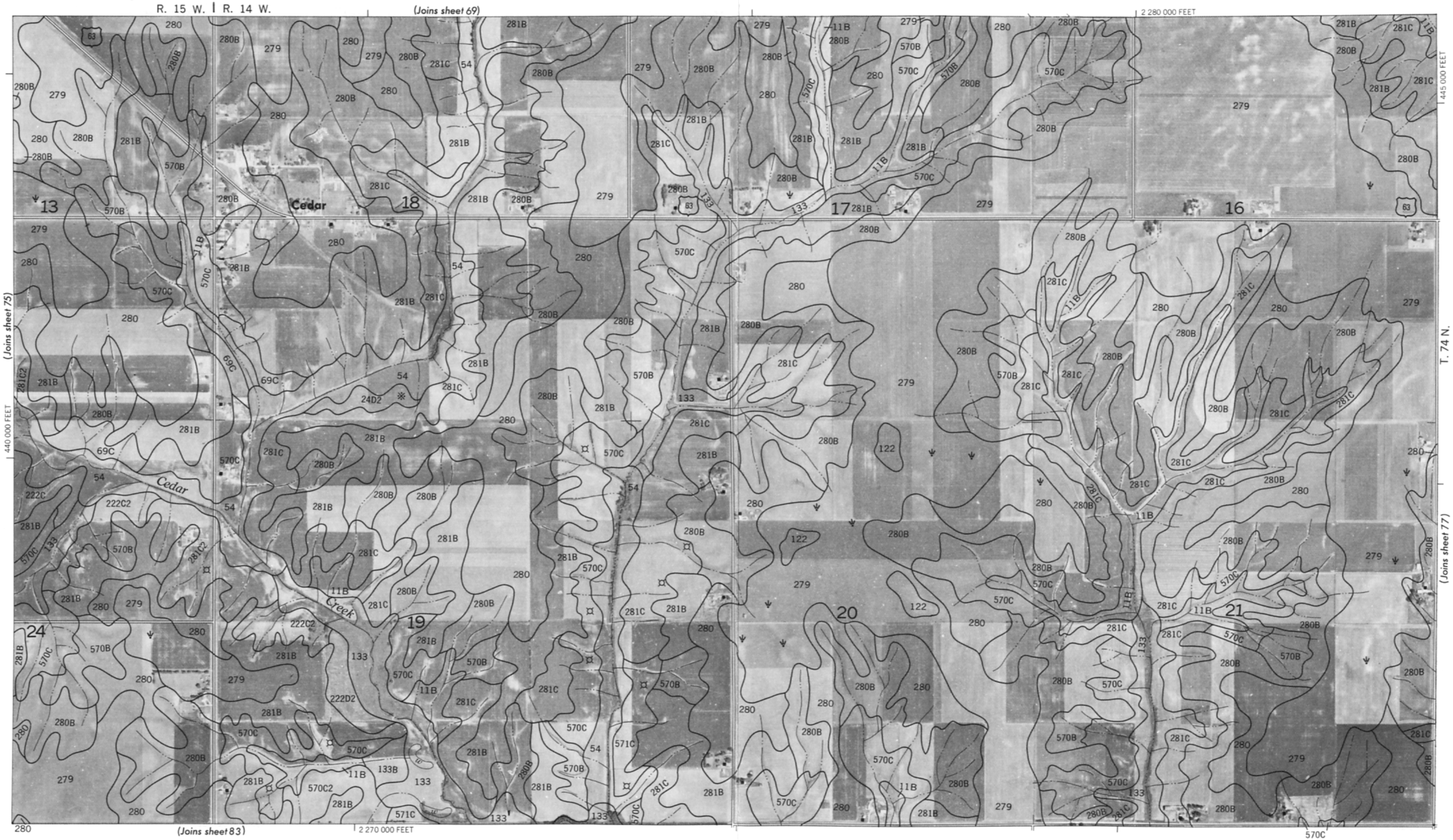

R. 16 W.
T. 74 N.
2 215 000 FEET
2 225 000 FEET
445 000 FEET
435 000 FEET
(Joins sheet 66)
(Joins sheet 74)
(Joins sheet 80)
(Joins sheet 72)
DES MOINES
RIVER
Creek
Bluff
Lakonta
MADE LAND
14
15
16
17
20
21
22
23

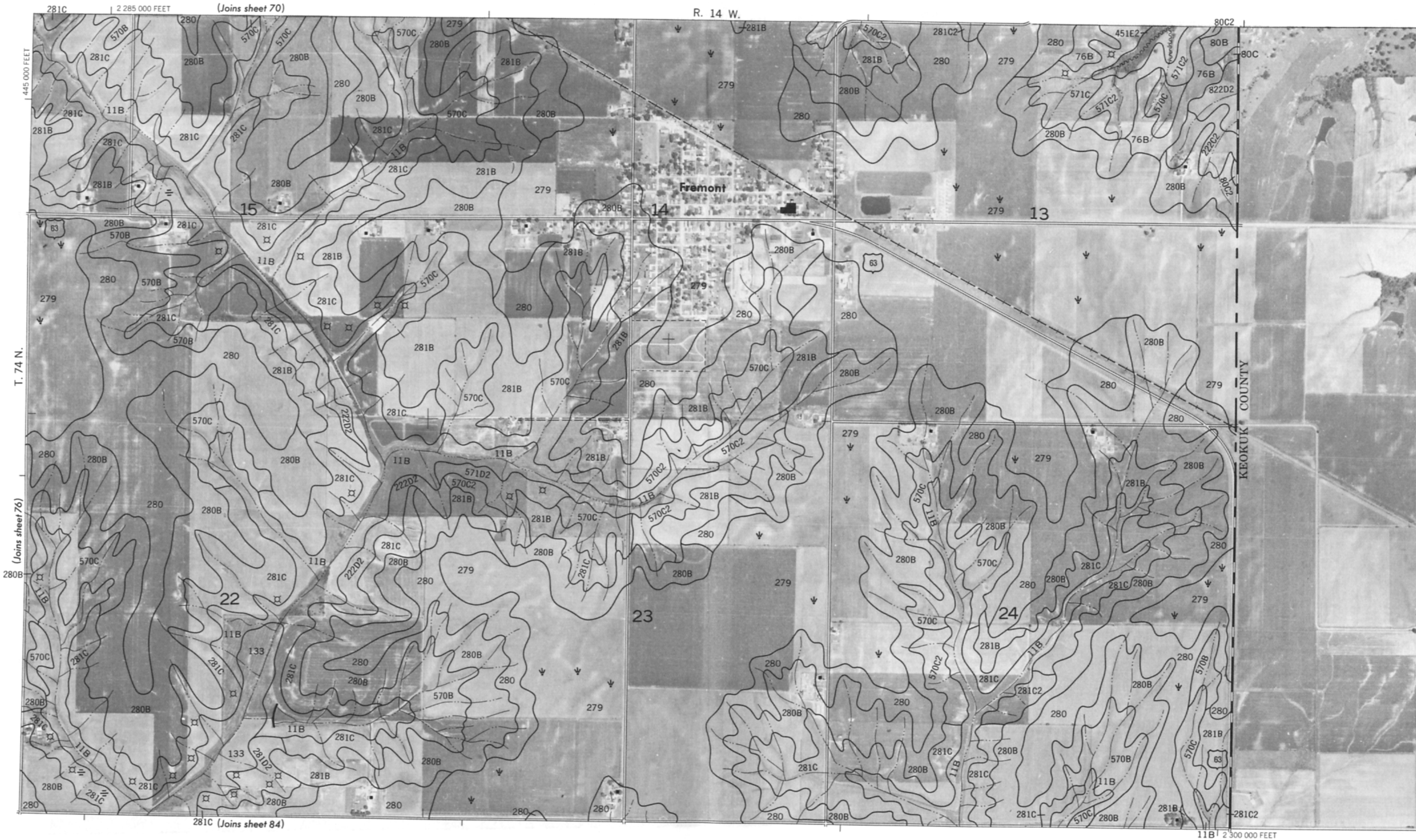

N
(Joins sheet 67)
R. 16 W. | R. 15 W.
2 245 000 FEET
445 000 FEET
(Joins sheet 73)
T. 74 N.
(Joins sheet 75)
(Joins sheet 81)
2 230 000 FEET
435 000 FEET
QUARRY
City Dump
CHICAGO
ROCK ISLAND
AND
PACIFIC
NORTH WESTERN
Muchakinock
Creek
14
13
18
17
23
24
19
20

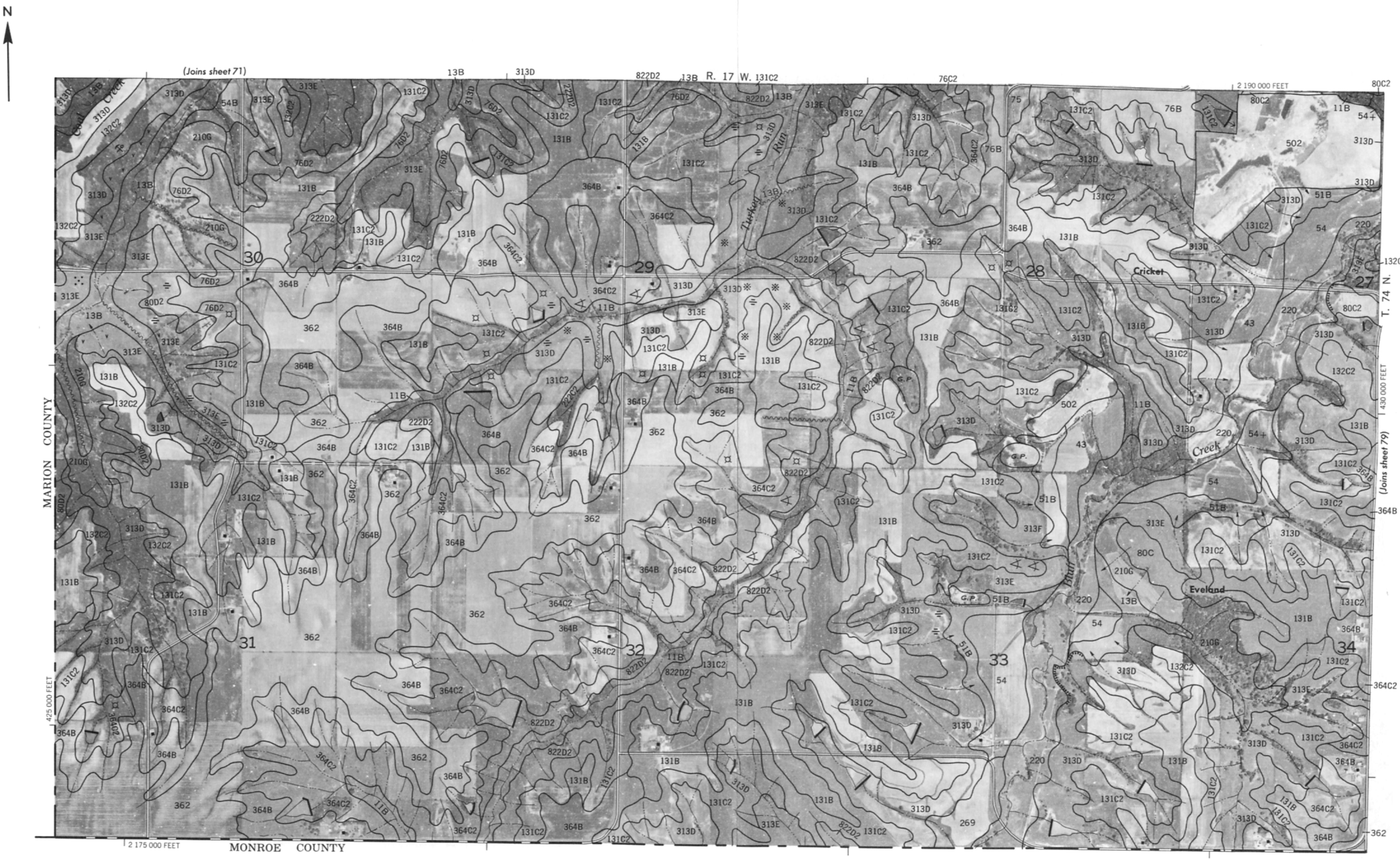
N


(Joins sheet 68)
R. 15 W.
2 250 000 FEET
445 000 FEET
T. 74 N.
(Joins sheet 74)
(Joins sheet 76)
440 000 FEET
(Joins sheet 82)
2 265 000 FEET
16
15
14
13
21
22
23
24
Cedar
Creek

N

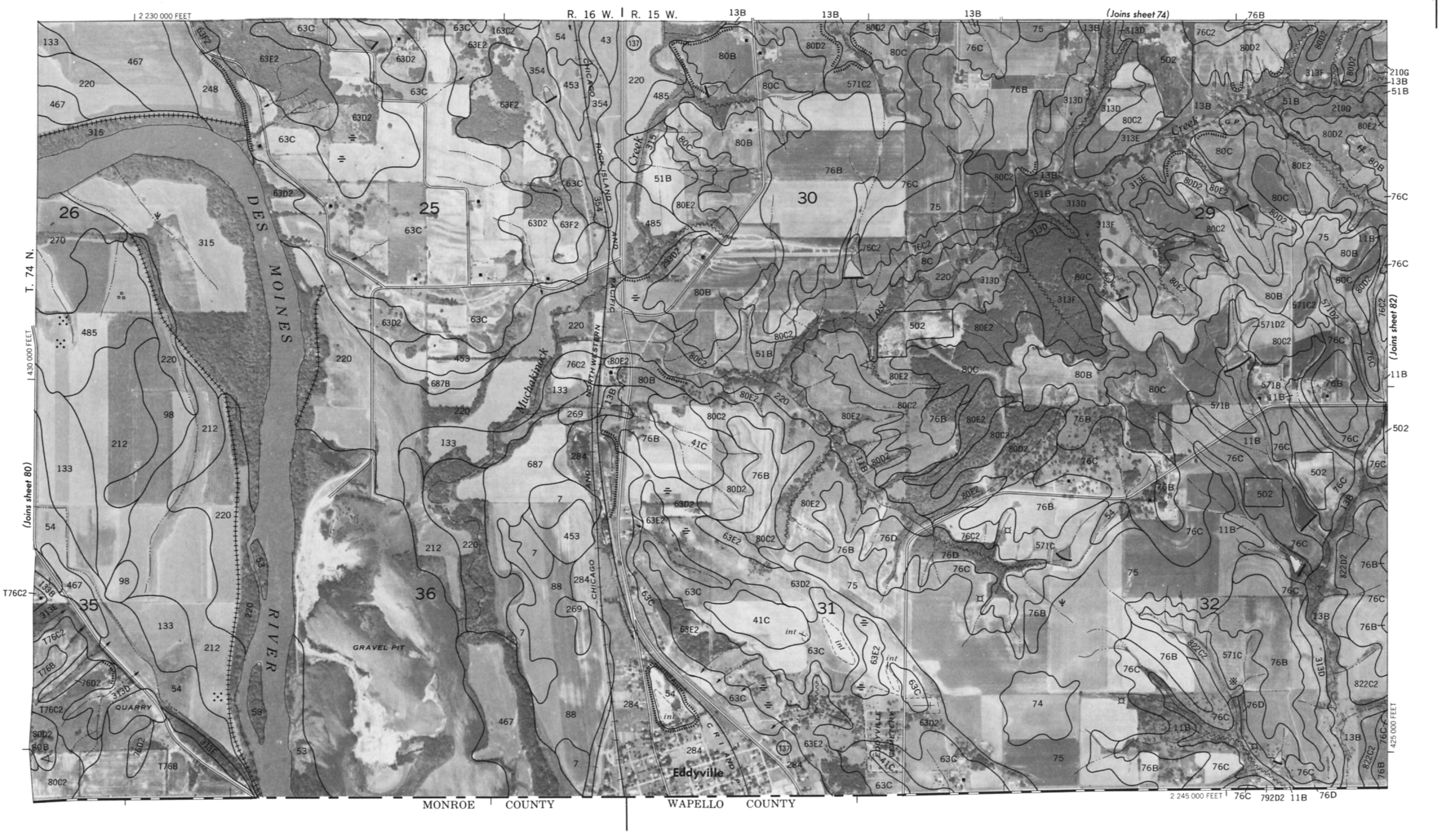

R. 15 W. | R. 14 W.
(Joins sheet 69)
2 280 000 FEET
445 000 FEET
(Joins sheet 75)
440 000 FEET
T. 74 N.
(Joins sheet 77)
(Joins sheet 83)
2 270 000 FEET
Cedar
Cedar Creek
13
18
17
16
24
19
20
21


(Joins sheet 70)
2 285 000 FEET
R. 14 W.
445 000 FEET
T. 74 N.
(Joins sheet 76)
Fremont
KEOKUK COUNTY
440 000 FEET
(Joins sheet 84)
2 300 000 FEET
15
14
13
22
23
24


N
(Joins sheet 71)
R. 17 W.
2 190 000 FEET
T. 74 N.
430 000 FEET
(Joins sheet 79)
MARION COUNTY
425 000 FEET
2 175 000 FEET
MONROE COUNTY
Coal Creek
Turkey Run
Creek
Bluff
Cricket
Eveland
30
29
28
27
31
32
33
34
G.P.

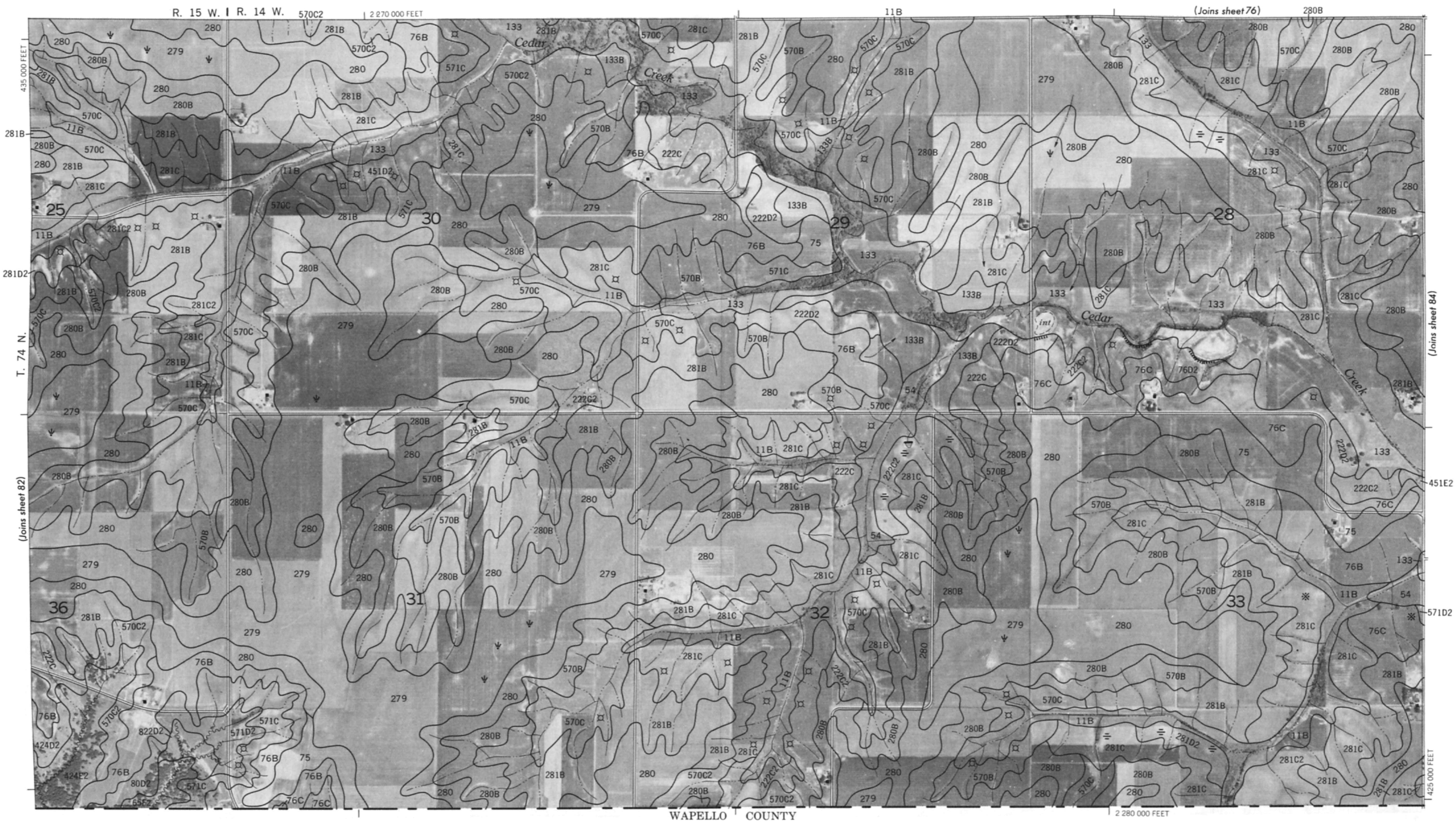

N
R. 17 W.
R. 16 W.
(Joins sheet 72)
(Joins sheet 80)
(Joins sheet 78)
T. 74 N.
2 195 000 FEET
430 000 FEET
425 000 FEET
2 210 000 FEET
Creek
Bluff
Creek
Bluff
Little
27
26
25
30
34
35
36
31
MONROE COUNTY


N
(Joins sheet 73)
R. 16 W.
2 225 000 FEET
(Joins sheet 79)
(Joins sheet 81)
T. 74 N.
430 000 FEET
425 000 FEET
2 215 000 FEET
MONROE COUNTY
Bluff Creek
DES MOINES RIVER
29
28
27
26
32
33
34
35


81
N
R. 16 W.
R. 15 W.
(Joins sheet 74)
(Joins sheet 80)
(Joins sheet 82)
T. 74 N.
2 230 000 FEET
2 245 000 FEET
430 000 FEET
425 000 FEET
DES MOINES RIVER
CHICAGO ROCK ISLAND AND PACIFIC
CHICAGO AND NORTHWESTERN
Muchakinock Creek
Lost Creek
GRAVEL PIT
QUARRY
EDDYVILLE CEMETERY
Eddyville
MONROE COUNTY
WAPELLO COUNTY
25
26
29
30
31
32
35
36


N
(Joins sheet 75)
R. 15 W.
2 265 000 FEET
435 000 FEET
(Joins sheet 81)
(Joins sheet 83)
T. 74 N.
425 000 FEET
2 250 000 FEET
WAPELLO COUNTY
Lost Creek
28
27
26
25
33
34
35
36

N


R. 15 W.
R. 14 W.
2 270 000 FEET
(Joins sheet 76)
435 000 FEET
T. 74 N.
(Joins sheet 82)
(Joins sheet 84)
425 000 FEET
2 280 000 FEET
Cedar
Creek
Cedar
Creek
int
25
30
29
28
36
31
32
33
WAPELLO
COUNTY

MAHASKA COUNTY, IOWA — SHEET NUMBER 84

N